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GENERAL SCIENCE.—*Man and science*[1]. RAYMOND J. SEEGER, National Science Foundation.

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One of the great issues today is the relation of man to science. I have deliberately used the phrase man and science, rather than science and man, to suggest that man himself is the key to the problem. I shall stress only the scientific aspect of this relationship today although I am quite sensitive to the human significance.

One phase of the issue may be stated thus: Is science inherently individualistic? If so, personal freedom is a primary requisite for each scientist. Or, is science essentially social? Then government planning is a fundamental necessity for all science.

The present emphasis all over the world seems to be on the social importance of science, arising probably from the prominent place it occupies in the economic structure of modern society (cf. the medieval social interest in astrology and alchemy). First of all, man is searching intensively for all kinds of materials and for cheap sources of energy, owing partly to catastrophic World War II losses, partly to normal population growth, and partly to an ever increasing demand for commodities. Secondly, the dramatic use of atomic energy within six years after its identification has encouraged a belief that the usual time lag between discovery and application can be greatly decreased by a sufficient expenditure of simultaneous efforts. (A more recent, but less well-known example from solid-state science is the invention of the transistor.) It is conceivable that the mastery of nature through science will make possible the mastery of the world. The uppermost question, therefore, in everyone's mind is this: if science is to rule the world, who is to rule science? Accordingly, we find governments generally sensitive to the basic research studies of technology. Sometimes, indeed, there is a deliberate attempt to make basic research captive, often indirectly through the support of education. For example, in recent years more than 60 per cent of education in Great Britain has been supported by the national government; in Germany about 90 per cent of all research at educational institutions has government funds for its source; in Russia technological development is being exploited in an all-out effort. Even in the United States it is estimated that the Federal Government supports about 70 per cent of the research performed at educational institutions. Hence it is not surprising to find President J. D. Millet, of the University of Miami, chairman of the Commission on Financing Higher Education of the Association of American Universities, saying, "Many of America's greatest universities are on the verge of becoming purely scientific, if not technological institutions." In any case the spectrum of the distribution of national funds for the support of science is anxiously watched as an index to technological progress.

Let us, therefore, consider in more detail the question: is science essentially social? Some years ago Julian Huxley concluded his book *Science and social needs* with the statement: "Science is not the disembodied sort of activity that some would make out, engaged in the abstract task of pursuing universal truth, but a social function, inti-

[1] Vice-Presidential Address for Section L, "History and Philosophy of Science, 1956 Atlanta Meeting of the AAAS. Based upon talks given at Purdue University, the Virginia Theological Seminary, Industrial College of the Armed Forces, and the State Department Foreign Service Institute.

mately linked with human history and human destiny." In the same spirit Hyman Levy in *The universe of science* has emphasized that science creates social needs, whereas Lancelot Hogben has boasted continually that science fulfills social needs. The Union of Soviet Socialist Republics notes in the Soviet encyclopedia that "The ultimate aim of all science is the satisfying of the needs of society." The Soviet Union itself is a good example of this thesis.

In the official Marxist doctrine of 1930 we are informed that science is identical with technology; that science advances practical needs; that science, therefore, must be organized for practical needs; and that central direction is necessarily part of economic planning. A dramatic illustration of this doctrine in practice was the recent development of biological science in the Soviet Union. In 1948 Lysenko expressed opposition to genetics because of its hereditary emphasis in contrast to the envoronmental factor, proper for Soviet thought. He was opposed also to Darwinian theories with their emphasis upon individual species combatting one another in contrast to the Lamarckian influence of environment. Within two years Michurin of Russia announced that through Lysenko's methods actual changes had been effected in plants, such as the transformations of wheat into rye, of elm into hazelwood, of pine into fir, et al. Two years later an announcement foretold animal changes soon to come (to date, the speaker has no knowledge of the fulfillment of this prophecy).

In practice the Soviet doctrine resulted early in a nationalization of science quite contrary to the international character that has been generally accepted in western culture. For example, in 1935 Soviet scientists were not permitted to publish in scientific journals outside Russia; later the Soviet journals themselves were published only in the Russian language; still later, references were confined mostly to Russian literature. To say the least, history may become greatly distorted through such a procedure. (The new look of the USSR is quite encouraging for an international outlook in the area of scientific publication (e. g., permission for external publication, and English abstracts of internal journals).)

If we would see ourselves as others see us, we might well read the somewhat prejudiced book of S. F. Mason, *Main currents of scientific thought* (1953). He argues that in the nineteenth century the main current of Soviet thought was essentially of a theoretical nature (cf. Lobachewsky's non-Euclidean geometry, Mendeléef's periodic table, Pavlov's conditioned reflexes), whereas in the United States it had more of a technological character (e.g., anaesthetics, the telephone, the airplane, et al., culminating in the twentieth century production of the atomic bomb). Perhaps, we should look critically in our own historical mirror. We see Benjamin Franklin promoting in 1773 the founding of the American Philosophical Society "For Promoting Useful Knowledge." In 1836 Joseph Henry, before his appointment as first Secretary of the Smithsonian Institution, said, "Though many excel in the application of science to practical arts of life, few devote themselves to the continued labor and patient discovery and development of new truths." With respect to Thomas Edison, Henry Ford remarked, "Today we think of scientific discoveries in connection with their possible or future application to the needs of man." In his *Science, the endless frontier* Vannevar Bush warned in 1945, "Our national preeminence in the fields of applied research and development should not blind us to the truth that with respect to pure research—the discovery of fundamental new knowledge and basic scientific principles—America has occupied a second place." Thus, we see from the beginning of American history to modern times a utilitarian tradition.

Nowadays there appears to be a worldwide phenomenon of such technological emphasis. On the one hand, those countries without industries are urgently striving to encourage industrial research; while, on the other hand, those countries with well-developed industries are busily engaged in fostering military research. In Great Britain, for example, during the period 1936–37 to 1950–51 the government support of basic research in the universities increased only sixfold, while government expenditures in-

creased 8 times in agricultural research, 9 times in medical research, 10 times in industrial research, and 67 times in military research and development.

In all this social emphasis upon science, to be sure, there always lurks the potential danger of undesirable control. Physicists are ever mindful of the meeting of the British Association for the Advancement of Science in 1847 at which James Joule's experimental conclusion of the conservation of energy would have been dismissed ex cathedra by the chairman, had it not been for the alert and sensitive intervention of a young man by the name of William Thomson, later Lord Kelvin. A tragic series of events took place in Germany partly because of Hermann von Helmholtz's failure to recognize the theoretical work of Robert Mayer on the mechanical equivalent of heat in 1842, even though he admitted its value at the Innsbruck meeting in 1869. We are all aware of the German decision not to develop atomic energy during World War II. An "expert" here once informed a class that supersonic flight of aircraft would never be a possibility—at the very time that the Germans had privately completed their basic aerodynamic research for the V-2. I myself still recall certain individuals who advised against sponsoring basic research on the long-range application of interferometry to jets because of a supposed urgency of a short-range duration. Then, too, I recollect the scoffing attitude of some persons who questioned certain theoretical work in favor of practical improvements amounting, say, to an increased efficiency of a tenth of one per cent. It turned out later, however, that the theoretical ideas became embodied in the air-burst principle used in the bombing of Hiroshima and Nagasaki with its untold percentage increase in effectiveness. Men of affairs unfortunately are not alone in being adept in making wrong choices. In his outstanding work on *Hydrodynamics* (6th edition) the scholar Horace Lamb mentions the basic Rankine-Hugoniot law of shock waves only casually (in a footnote), viz, "No evidence has yet been adduced in support of this law." Yet since that year of 1933 shock waves have assumed a major role of practical importance and of theoretical significance. It is evident that the high stakes involved in wrong choices make the management problem of judging social significance a matter of utmost importance. Even though control of science by scientists is not without serious problems and handicaps, there would appear to be an even greater danger if the development of science should be controlled by nonscientists—for motives other than scientific progress.

What is more, there is always also a limiting manpower problem in any social endeavor. Some time ago a representative of a foreign oil company pointed out from an analysis he had made, that research output has apparently doubled every seven years in recent times. He estimates that just one more effective doubling is possible owing to the limitation of sufficiently intelligent persons available for guiding basic research in a balanced economy. Regardless of the correctness of the prophecy, evidently the availability of scientific personnel at any particular place and time does impose an upper limit so that efficient utilization of people may be of primary significance. In our own country we note the rapid depleting of scientific personnel in colleges and universities owing to the increasing competition among industries for technical talent at the very time when schools are beginning to bulge. It may well be that in this process we are all robbing the academic goose who lays the intellectual eggs. France long ago pointed to a more likely road to scientific achievement in the establishment of the École Polytechnique with its utilization of research-minded individuals as teachers.

Is science, perhaps, inherently individualistic? There is no doubt that much scientific growth has psychological and sociological roots in more or less practical requirements. It must always be borne in mind, however, that intellectual curiosity per se also is often a primary incentive. The element of wonder and astonishment is always a pertinent motivating factor. Newton himself, when asked about his own discoveries, stated that he had made them "by always thinking aside about them." In more recent times, X-rays were discovered as a serendipity biological by-

product of a physics investigation. In the scientific laboratory, as well as in kindergarten, the intellectual activity must be fun. Perhaps, here is a clue to the scientific productivity of young people—their attitude toward real problems, rather than the condition of their environment. Strangely enough, Einstein as a young man made his brilliant discoveries about special relativity, the Brownian movements, and the photoelectric effect not in a university, not even in a laboratory, but in a government patent office. Not only must we bear in mind socially that scientists are people, but individually that each scientist is a person—a person that sees visions and later dreams dreams. He is not so much a doer—or even a knower—he is truly a seer. Poincaré once noted, "It is not science that is useful because its discoveries make technical progress possible but technical progress is useful because it enables mankind by relieving it of material cares to give more time to science and to art."

Science, indeed, is fundamentally not so much a common-sense residue from the past, but rather a challenge to the common sense of the present. Perhaps, a familiar illustration may be useful. Here is a trailer with a candle in the center. When the candle is lighted, will the rays of light reach the front end or the back end of the trailer first? It is obvious that both will take place at the same time. I forgot to mention, however, that the trailer is moving (unknown and unknowable to the occupants)—or is it the earth that is moving? To persons on the outside it is equally obvious that light will reach the back end of the trailer before light arrives at the forward end, which appears to be moving away from the initial position. In other words, to these observers, the events are not simultaneous. The only knowledge used in making these two contrary deductions is the experimental fact that the velocity of light is the same for all observers regardless of their own state of motion. Thus the common-sense concept of simultaneity, which seems generally intelligible and self-evident to us, is challenged by science. It should be emphasized, however, that the real contribution of Einstein in this instance was to call attention not to the doubtful conclusions relative to different observers, but rather to the certainty resulting from that which is invariant with respect to all observers.

Another challenge to common sense is seen in the very nature of energy. Here we find that by exercising discipline with regard to logical consistency we arrive again at greater freedom of thought. Let us take another familiar example, say, a space ship having two radio emitters inside, one at each end. The first station emits a radio beam consisting of electromagnetic radiation. It is known that such waves have momentum given by E/c, where E is the energy of the radiation and c its velocity. The action on this emitted radiation is associated with a reaction on the space ship, which obtains an opposite momentum given by Mv, where M is the mass of the space ship and v its resultant velocity. During the time t that the radiation travels the distance l from the first station to the second one, where it is received, the ship will have moved a distance x, given by vt. There is no apparent reason why the two radio stations cannot then be interchanged (in principle), and the whole process repeated over and over again. In this event the space ship would move on indefinitely in the same direction—a violation, of course, of the conservation of energy. In what respect, then, have we been theoretically inconsistent? We have not associated any mass with the radiation. Accordingly, in interchanging the stations we have failed to preserve the location of the center of mass of the whole system. In other words, Mx must equal ml, where m is the mass of the emitted radiation. From these few relations we find readily that the unknown mass m of the radiation is equal to E/c^2. In this simple way we have obtained an expression for the mass equivalent of radiation energy; and so we are compelled to think of atomic (mass) energy, in addition to mechanical energy, electrical energy, thermal energy, et al.

Perhaps, the greatest danger, however, that exists for the individual scientist who hopes to be free to see such visions, is the polluted atmosphere of materialism. To many people science has become socially just a magic phrase for nature like "open

sesame," which will reveal money for many things close to the heart's desire. As a graduate student, I heard a college preacher remind the students upon the occasion of a great monetary gift for buildings that universities consist not of things, but, in the main, of ideas. How sad it is to see inside many large edifices with magnificient equipment the obvious imprint "No men—at work." A more dangerous personal influence is the subtle, often subconscious lure of higher salaries, extra privileges, more power, which might even be called professional patronage in the vulgar sense. We are ever reminded that "man does not live by bread alone," that

> The world is too much with us, late and soon,
> Getting and spending, we lay waste our powers,
> Little we see in Nature that is ours.

Einstein remarked in his introduction to the 1931 reprint of Newton's *Optics*, "Fortunate Newton, happy childhood of science, he who has time and tranquillity can by reading this book, live again the wonderful advantages which the great Newton experienced in his young day." Time and tranquillity, rather than material benefits, these are the prerequisites for the individual scientist who wishes to understand the world about us!

Thus I find myself concluding that science is inherently individualistic in its origin, but essentially social in its development. Basically, it is man made and hence anthropomorphic. Let us consider, therefore, what science is.

Science, I should say, is strictly the result of the use of the scientific method and the scientific method is simply the instrument used by the scientist. The answer to the question, what is science, is given basically in terms of the scientist. A related question, of course, which we shall not be discussing today, is this one, "Who is man?"

In science we begin existentially with sense impressions, which change with our own impressionistic outlooks and which in their totality constitute observed facts. To many non-scientists science is nothing more than a collection of such observed facts—or at most combined with some inductive inferences, as in the early positivism of August Comte. It was recognized later, however, that a scientist just doesn't collect facts at random in the tradition of Francis Bacon. Who, for example, would note all the motional aspects of fluttering leaves in order to ascertain the general laws of motion? On the contrary, one carefully selects facts together with their relations, which constitute the later positivism of Ernst Mach. It has become evident that the more popular or general a language the more even simple interpretations of facts require some kind of semantics, or operational rules, as advocated by modern logical positivists. For example, what do we mean scientifically by the length of a body? No more than the answer we get in making a measurement, either thoughtfully or experimentally, in a certain prescribed manner regardless of any preconceived categories of knowledge! We note that in each case it is the scientist who collects, the scientist who selects, the scientist who operates.

Any person having objects of different sizes, shapes and colors will attempt to separate out those that are alike and, if possible, to relate those that are different into a single pattern. So, too, the scientist looks for related factors amid his collection of observed facts. In this respect, he may be guided by the cogency of logical consistency, or by the urgency of simplicity for economic or some other purposeful convenience. For example, it is well known that a descriptive characteristic of a material is its specific gravity, that is, the weight of a given sample relative to the weight of an equal volume of water. It is equally true, however, that the square of the specific gravity is also uniquely characteristic—not to mention the cube, etc. We prefer to utilize specific gravity because of the simplicity of its form. Here again it is the scientist who chooses the relations.

To the traveler who has gone along various roads and who has seen many places, it is always refreshing to go up on a mountain top from which he can see at a glance the whole surrounding region with its network of roads. So, too, the scientist is not content with the observed facts, or even with the related factors. He looks for an overall view, what the Greeks called a theory (from the

same root word as theater); such a theory is necessarily factitious in that it is inspired in the scientist by compelling beauty or by ingrained truth (based on analogies with common sense), or merely by the heuristic value of pragmatism. Not everyone could or would or should be an Einstein, a Bohr, et all. Max Born concludes his "Natural Philosophy of Cause and Chance" with the remark "Faith, imagination, intuition are decisive factors in the progress of science as in any other activity." The scientist is truly a maker, or to use the Greek word, a poet. In a strict sense the scientist strives to achieve a poetical view; his formal relations are freely creative, as Poincaré has emphasized. Hence the scientist himself plays a major role in the development of theory. He can never be completely eliminated. The studied attempt to eliminate the subject for greater objectivity finally becomes only increasingly more subjective.

Every scientist has a question in mind as he looks out upon the world about him. The observed facts are its answers. From them he obtains related factors. From both he makes a factitious theory, which enables him to see farther and wider so that new questions arise in his mind as he again looks out upon the world about him. The new answers are in the form of additional observed facts. The cycle will be continually repeated, although its completeness will ever depend upon the controllability of the material. For example, observed facts may be difficult to isolate as in self-involving social phenomena; or a factitious theory may be difficult to achieve as in the omnipresent observational earth sciences. In any case the cycle represents a single instrument in the hands of an instrument maker.

In the use of the scientific method, however, there are two necesary conditions. The first one is conformity to nature, which is based upon the assumption of the uniformity of nature. In other words, at all times predicted conclusions must check with observed data.

The second condition is acceptability by society, which is based upon the assumption of human comprehensibility of nature. Einstein once said that to him the most incomprehensible feature of nature is its comprehensibility. The scientist's understanding, his reasons for accepting certain general principles, depends on his own personality as well as the social class, the political group, the religious faith, et al., to which he adheres. In a strict sense such factors are included in the sociology of science. In the celebrated case of Galileo, we note, the Roman Catholic Church opposed philosophically the favored position of the sun. (One wonders what influence this social problem may have had later in the eighteenth century, which saw science in a dormant state both for the Catholic Italy of Galileo and for the Protestant Germany of Kepler, which was undoubtedly influenced by the antirational attitude of Luther.) In our own day we found Nazi leaders, with the physicist Johannes Stark as their spokesman, voicing similar opposition to the lack of favored observers from the relativistic point of view. They were opposed also to the concept of materialistic clocks for time determination, which seemed irreconcilable with their own idealistic position. On the other hand, in the USSR also there has been official opposition to the relativity theory, but in this instance because of a supposedly idealistic view of material mass as energy. (Can it be altogether accidental that the use of atomic energy was first developed in English-speaking countries?) The social acceptability of science is intrinsically involved in the philosophy of science, again impressing us with the fact that in all science there is indelibly imprinted something of the scientist himself.

As we look about us, we are aware of phenomena, appearances that play like Plato's shadows in his underground den. It is upon the foundation of the totality of these sense impressions, of course, that one constructs the world of science. Here, however, is always an element of surprise—the theories are never merely descriptive of what is known; in addition, they are predictive of what is unknown—probably due to the fact that a thing itself is always greater than any experiential impressions and, even more so, than any symbolic expressions of it. That there is a world of nature beyond sense impressions gains cre-

dence as a philosophy of nature extrascientific (metaphysical) in character. Thus we find Max Planck insisting upon the existence of three worlds: the world of sense impressions, the world of science, and the real world, as he calls it. He says "Physical science demands that we admit the existence of a real world independent from us" —actually, an assumption. As far as I can see, the data of sense impressions form a contact surface of phenomena, in which I am existentially involved, between two possible worlds, the world of nature and the world of science. What relationship, if any, exists between these two worlds? Is nature possibly non-existent? Is science, perhaps, purely fictional? Is science merely the imperfect reflection, or imperfect image of nature made in the rational image of man? Are these two worlds possibly identical? Is science a re-construction of the world of nature? There are various views as to how the world of science may be related to the world of nature. P. Duhem urged "To the extent that physical theory makes progress, it becomes more and more similar to a natural classification which is its ideal end." Einsten stated, "Our experience up to date justifies us in feeling sure that in Nature is actualized the ideal of mathematical simplicity." A. A. Michelson once suggested that "What can surpass in beauty the wonderful adaptation of Nature's means to her ends, and the never-failing rule of law and order which governs even the most apparently irregular and complicated of her manifestations? These laws it is the object of the scientific investigator to discover and apply. In such successful investigation consists at once his keenest delight as well as his highest reward." We are reminded here of Keat's creed that "Truth is beauty." P. Bridgman, however, cautions us that "The known laws of nature are simple if we consider only a limited range of facts." Hence we must always be aware of limitations of scientific data, which are necessarily incomplete and imperfectly described by man. We must be conscious also that the world of science, in turn, is necessarily incomplete as a description even of the sense impressions, not to mention as a description of their matrix; at best it represents only an incomplete and imperfect theoretical outlook. Uniqueness, of course, is always wanting. It would seem unlikely, therefore, that a one-to-one correspondence would exist at any time between the world of nature, involving the sense-data plane, and the world of science, involving the same plane. One would hardly be justified, I believe, in any extrapolation like that of P. Jordan in his *Science and the course of history*, viz., "The discovery of new laws of atomic physics has shown the old materialistic view to be untenable even in the field of physics." The necessary conditions of conformity to nature and of acceptability by man, moreover, may be related to the philosophy of nature as a guiding faith. To me the cumulative and integrative development of scientific theories, leading to more inclusive description and ever surprising prediction, points more and more to a probable world of nature, which may be susceptible of metaphysical interpretations, such as the theological premise "In the beginning God"! We should never dogmatically exclude Einstein's "Faith in the possibility that the regulations valid for the world of existence are rational."

Unfortunately there is a widening gap between any philosophy of science approached from the standpoint of science, and any philosophy of nature, approached from the standpoint of philosophy per se. Yet there can be no sharp line of demarcation; for the scientist himself is the link. As man looks at the environment about him from the different points of view of physical, biological, psychological, and sociological sciences, it is always he himself who is viewing. Invariably, from any viewpoint he ponders three questions: what is true? what is real? what is value? The attempt to obtain answers to these questions in any discipline may properly be called the philosophy of that discipline. To seek common answers to these common questions is general philosophy. The attitude may be that of an agnostic, or of a skeptic, or of a man of faith. No compelling evidence will be agreed upon by all viewers. Because of inevitable incompleteness the same set of observed facts may be seen in different ways—as a cube may be visualized on a flat surface, or as a limited outlook of white clouds in a blue sky

may be interpreted as white caps on a blue sea. As far as I can see, there is no way of demonstrating just what is precisely true and just what is precisely false; for there are no general criteria for truth. The choice for each of us may be determined by unconditional imperatives like loyalty to a human cause, like love to a human partner, like obedience to a divine Will, et al., or merely by unconditional recognition of other people as individual persons. What must be admitted by all is that civilization is the product not of the pessimism of agnostics and of skeptics, but of the optimism of men of faith. Enthusiastic men have varied as to what they have believed, but they have all believed either in some thing, or in some one, or in Some One. Some have believed that answers to the three questions can be obtained from one's environment (materialism); others, from men (humanism); still others, from God (theism). Unfortunately, while a man considers leisurely how to make up his mind, he may already be virtually making up his life. Three practical decisions are open to every man. He may refuse to consider the matter and thereby fix his ignorance; or he may purge his beliefs and thus leave a vacuum for chance filling in; or he may clarify all aspects and then make an intelligent (from the Latin words inter legere meaning to choose among) choice. We note that detachment is itself a choice.

What then shall we do about the original question, is science inherently individualistic, or essentially social? Dr. Conant, I believe, gives us a clue when he says "Science should be relevant to man." In other words, as men, we can not have science for the sake of science any more than we can have art for the sake of art. We must have science and art for the sake of man—man individually or socially. Science is both an *end* for man and a *means* for society. The best results will be obtained, of course, if their interrelations are understood. Freedom for the individual, I would urge, should be listed first. Man is truly a social being; but first of all, a man is actually a man.

When I think of man and science, I find a parable in the apotheosis of Faust, as set forth in that poetical, philosophical autobiography of Goethe. The theme there seems to be that he who strives, strays, yet in that straying finds his salvation. At the beginning Faust flouts science. He tries vainly to make man master of his environment. Mephistopheles taunts Faust with his demand for everything, his satisfaction with nothing. He wagers that Faust will one day demand nothing, but will be satisfied with whatever chance throws his way. In the last scene we watch expectantly the 100-year old Faust looking upon the sand dunes along a shore marked with engineering feats of dykes and canals—a political enterprise in which people strive daily to make buttresses against the ever-surging sea. Faust muses on future generations living and laboring in this wholesome danger. He mutters, "Verweile doch, du bist so schön" (Stay, thou art so fair)—almost the very words of the original wager. Yet even here Faust is maintaining his enthusiasm for a difficult, but endless life:

> The noble spirit now is free
> And saved from evil scheming!
> Whoever aspires unweariedly
> Is not beyond redeeming.

ETHNOLOGY.—*Stone "Medicine Wheels"—memorials to Blackfoot war chiefs.* HUGH A. DEMPSEY, Calgary, Alberta. (Communicated by John C. Ewers.)

Two stone "medicine wheels," which are still in existence on the Blood Indian Reserve in southern Alberta, Canada, offer excellent examples that the line between archeological and ethnological work is sometimes a fine one. For these two "medicine wheels"—and a third recently inundated by backwaters of St. Mary Dam—are not ancient markers whose significance is lost in antiquity. Rather, they have been constructed within this century, and a summer's field work has revealed the date and ownership of the rings, the reason for their existence, and has enabled interviews to be made with individuals who actually participated in or witnessed their creation.

The Blackfoot "medicine wheel" consists of a circle of stones, or "tipi ring," with concentric lines of stones of varying lengths extending away from it in the four cardinal directions. This pattern is similar to those described by Kehoe's informants (1954, pp. 133–34), although it differs from his Lowry, Mont., site which has ten such lines.

The tipi ring itself is common in Blackfoot country and has been used within the past two decades by at least two tribes of this nation (Blood and North Peigan) where the owner wished to follow early customs.

The tipi rings were aptly described in 1955 by One Gun, an elderly North Blackfoot informant: "The circles of stones were normally used to hold down the edges of the lodges. The old tipis were made of buffalo skins and were much heavier than the canvas ones. They could not be blown away as easily, so stones were able to hold them in place. But when we started to use canvas, we had to use pegs or our tipis would be blown over. Stones were also used between the pegs."

Although many of these tipi rings have been destroyed in cultivated areas, some are still known to exist on the North Blackfoot Reserve in Canada, the Blackfoot Reservation in Montana, and on the Blood Reserve, where the writer has observed well over two dozen in casual traveling.

The Blackfoot term for the "medicine wheel" is *atsot-akeeh' tuksin*. The literal translation is: "from all sides" (*atsot*), "a small marker of stones" (*akeeh'*), "for posterity" (*tuksin*). It will be noted that the word merely designates the radiating lines and makes no reference to the tipi ring itself. This conforms with Blackfoot tradition that the lines were merely appendages to existing tipi rings, rather than the whole marker being constructed at one time.

According to informants, "medicine wheels" were used to mark the residence or grave of a warrior chief. There were apparently three such allied uses: for a tipi in which a warrior chief died and was buried; one in which he had been residing at the time of his death but which was not his burial place; and one which was used during his lifetime but not related to his death. Each may be a variation, or they may reveal a change in the use of these markers over the years.

The earliest reference to a Blackfoot "medicine wheel" known to informants is credited to Bull Back Fat, a Blood chief who died in 1842. But, according to Jack Low Horn, a reliable Blood informant who supplied this data, the marker did not originate with this chief but "was started in the days when our people used dogs instead of horses." The informant told the following story:

"The use of this sign saved the life of the first Bull Back Fat.[1] The Bloods had been on a raiding party to the south and were returning home. In each camp, Bull Back Fat used these signs around his lodge. A party of enemy Crows discovered one of these camps and saw his marks. They had never seen them before and wondered what they meant, so they began to follow the trail of the Bloods. They found two deserted camps and arrived at the third shortly after the Bloods had left. Bull Back Fat and his wife were a few miles from this camp when they discovered that a colt

[1] There were at least five Blood chiefs named Bull Back Fat during the period 1830–1900 and each is remembered by some characteristic—i.e., the first Bull Back Fat, the short Bull Back Fat, the Bull Back Fat who was buried by women, etc.

had been left behind, so they returned to find it. When they came to a point overlooking the camp, the Crows saw the pair and waved to them. Escape was impossible, so Bull Black Fat rode down to meet them. Speaking in sign language, the Crows asked about the meaning of the stones. Bull Back Fat explained that these were used by a great warrior chief who was leading the party of Bloods; but he did not tell them that he was the chief. They became anxious to visit this man and Bull Back Fat agreed to lead them there under a pact of peace, but asked that his people have time to be prepared. He left the Crows and found the new camp where his lodge was placed in readiness for the visitors. When the party arrived, they were shown to Bull Back Fat's tipi. When they entered, they were surprised to meet the same man whom they had seen earlier. It was then they learned who he was and realized they had missed the opportunity of killing a great chief. . . ."

According to the informant, other tribes soon learned the meaning of the "medicine wheel" and it served a practical purpose, for the enemy was always hesitant about pursuing a camp which was led by a noted warrior. "Anyone passing one of these markers would know that a great warrior chief had camped there," he commented.

If this at one period was the common Blackfoot use of the "medicine wheel," it evidently underwent a change in the late nomadic period, for most modern informants consider these to be solely memorials or death markers. One Gun stated that "when a chief died, he was left in his tipi. After it had fallen down and rotted, anyone travelling past would know that a chief died there because of the radiating lines." Alternately, Rides at the Door, a Blood informant, said that "any stranger passing such a place would recognize that a chief

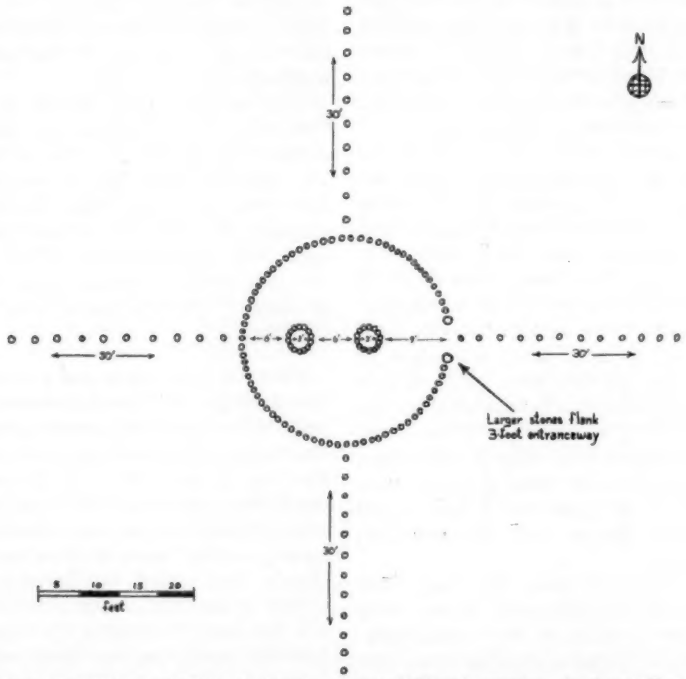

FIG. 1.—The "medicine wheel" of Steel, a noted Blood warrior, is located on the Blood Indian Reserve, southern Alberta, about 3 miles north of Spring Coulee. It is 27 feet in diameter at the circle with four 30-foot radiating lines. There were 77 stones used in the circle portion, and 14 each in the 3-foot fireplaces. This "medicine wheel" was constructed in April 1940, following the death of Steel.

FIG. 2.—The Eagle Child "medicine wheel," looking northeast.

had died there, but the body would not be left there."

It is possible that these two distinct lines of thought are the result of Blackfoot mortuary customs. At times, particularly during plagues or when moving camp, a dead person was left in his sewn-up lodge. On other occasions, he was buried in the trees or on a scaffolding on a high hill. This variation possibly affected the use of the "medicine wheel," with the radiating lines being left at the death lodge if it was used, or at the tipi ring if the chief was buried elsewhere.

The Bloods and North Blackfoot know of several "medicine wheels" which were erected for warrior chiefs. Some of these markers are still in existence, but most have been destroyed by the inroads of civilization. One Gun knew of two wheels which he claimed were intact on the North Blackfoot Reserve, east of Calgary. He said that "at Blackfoot Crossing there is one for Little Medicine Pipe, a Blackfoot who died in the smallpox epidemic of 1869–70, and on Arrowwood Creek is one for Bad Head, a Blood chief." Another informant said that Many Spotted Horses, a noted Blood war chief who died in 1884, had a "medicine wheel" on the Blood Reserve near Whoop-Up. A search revealed only this chief's tipi ring, but the stones of his "medicine wheel," which were at an inaccessible point on Weasel Fat's Bottom, had reportedly been scattered. Local Indians had replaced the stones as much as possible, but it was felt that this interference limited the usefulness of this wheel for comparative study.

However, two existing "medicine wheels" belonging to other Blood warriors were closely examined, and data was obtained on a third ring which in 1950 was submerged by the backwaters of an irrigation dam project.

The two inspected were the "medicine wheels" of Steel (*Ski-mátsis*, literally Fire Steel) and Eagle Child (*Péta-poka*), while the third belonged to Red Crow (*Mékaisto*). All these wheels were constructed during the present century and are likely the only ones made by the Blood tribe during that period. A similar "medicine wheel" has been credited to Running Wolf, a Blood chief who died in 1921, but conflicting stories tend to dispute the authenticity of the claim.

Of the three markers, Red Crow's is the earliest. It was made immediately following his death on August 28, 1900. Red Crow was head chief of the tribe from 1870 until

his death and was one of the most influential men in the nation. An elderly informant, Mrs. Bruised Head, who was present at the event, provided the following description of the making of his "medicine wheel":

"I was staying at Red Crow's tipi at the time. He went across the river to round up his horses and, when he didn't return, his wife, Long Time Singer, went to look for him. She found him laying on the gravel at the edge of the river. I saw her crying and we knew what had happened. We all went across with the Red Crow's wagon and brought his body over. Both religious denominations were at the funeral, together with many white people. When it was finished, we started to move camp. But before we left, we placed the markers on the four sides of his tipi ring. Red Crow had used pegs on his tipi, but also had stones between them. When the lodge was removed, the circle of stones was incomplete, so we took rocks from other tipi rings and completed it. Then we placed the four radiating lines. There was no ceremony; several of us in the family did it because it was the custom as far back as the days when we used dogs; they were just the marks of a warrior chief.

"After this, we left the camp site. That night, Bull Horn, a minor chief, camped in the next bottom. He had not heard about Red Crow's death. Next morning he went to the camp site and when he saw the marks around Red Crow's tipi ring he began crying, for he knew that Red Crow was dead."

The second example is the Eagle Child wheel which was constructed in 1931 after this man's death. It is located about 150 feet west of his house on the Blood Reserve, and 1½ miles south-west of St. Paul's Anglican School. The tipi ring portion is 12 feet in diameter and contains 54 field stones ranging from four to 12 inches in diameter. There are no hearth stones. When examined in the summer of 1955, the north and south lines contained six stones, the east line seven stones and the west line four stones. All extended in lines four to six feet in length and, by the spaces, would appear to have been disturbed by cattle or horses.

According to available information, Eagle Child had lived in his house, but moved to his tipi shortly before his death in 1931. The radiating lines were set in place by Francis Eagle Child following his father's death.

The most interesting "medicine wheel," from all aspects, is the memorial to Steel, a great Blood warrior. It is of the most classic design and the fact that it was constructed in 1940, probably makes it the most recent and last such stone marker.

Born in about 1850, Steel was an outstanding fighter against the Crow and Assiniboin and, although he never gained official chieftain status, he was held in this regard by his people. For his exploits, he became the owner of a 30-buffalo tipi and was permitted to have two fireplaces. Because these two points are reflected in his "medicine wheel" they should be briefly explained.

The average Blackfoot tipi contained 12 to 14 skins (Ewers, 1955, p. 131), but warriors who performed certain brave deeds were permitted to have tipis made of 30 buffalo skins. Because of its size and weight, such a lodge was said by informants to have been divided in half for moving, and was carried on two travois. Therefore, besides fulfilling the warrior requirements, the owner of such a tipi had to be fairly wealthy in horses. Some Bloods who owned these tipis were Seen From Afar, brothers Hind Bull and Fish Child, Packs His Tail, and Holy Sleeps. Naturally, a 30 buffalo tipi was far larger at the base than the average tipis, and this size is immediately evident when inspecting certain tipi rings or "medicine wheels."

If a Blackfoot owner of a 30 buffalo tipi carried his bravery and heroism to an even greater degree, he might become one of the select few to possess twin fireplaces. To gain this envied prize, a warrior had to perform some outstanding *coup* of a double nature. For example, an early Blood chief, Big White Child, knocked two enemy from the same horse—one from each side. Steel, according to an informant, gained twin fireplaces when he killed two Crow Indians in a singularly brave action.

The fireplace nearest the doorway was apparently used for everyday purposes, while the one to the west was reserved for

burning incense associated with a medicine pipe held by twin fireplace owners.

Informants knew of only five Bloods who had possessed both 30 buffalo tipis and twin fireplaces. These were the first Bull Back Fat, Tail Feathers Coming Over the Hill, Big White Child, Many Spotted Horses, and Steel. Even Seen From Afar, remembered by the Bloods as their greatest chief, had not performed the "dual" exploits necessary to gain this honor.

Therefore, Steel's final memorial—a 30 buffalo tipi ring, with twin fireplaces, and flanked with four radiating lines—would appear to be the greatest tribute that could be paid a Blackfoot warrior chief.

In his later life, Steel was a progressive Indian who lived in a log cabin, built corrals, and owned cattle and horses. Early in 1940, shortly before his death, he pitched his large canvas tipi (of 30 buffalo size) a short distance south of his home, in preparation for a meeting of the Horn Society—a secret organization which guides the religious life of the reserve. Although he used pegs, he also obtained stones to hold the canvas in place. Following the meeting, Steel showed his son, Bob, how to lay out the four directional lines.

Steel died at Standoff on April 7, 1940, and was buried on a hill near the Belly Buttes. His son, assisted by his sister, Mrs. Laurie Plume, then completed the "medicine wheel" in accordance with his father's last wishes.

"The lines signify that he was a brave man, a leader who had been to war," stated his daughter. "It was Steel's wish to have this done as a proper tribute to a warrior chief." She added that, if he had not been entitled to it, the elders of the tribe would have quickly ordered the stones removed, as they were jealous of undeserved honors.

The Steel "medicine wheel" is located on the Laurie Plume farm, three miles north of Spring Coulee and about three-quarters of a mile from St. Mary River.

The tipi ring portion is 27 feet in diameter (compared to Eagle Child's 12-foot ring) and contains 77 field stones. There is a three-foot entrance to the east which is flanked by two larger stones. The concentric lines are all 30 feet in length, with the stones evenly spaced. The north and west lines contain 10 stones while the south and east lines contain 12 each.

The double fireplaces are both three feet in diameter and each contains 14 stones. The everyday fireplace is nine feet from the east entrance, while the ceremonial fireplace is six feet in either direction from the west edge of the ring and from the other fireplace.

There is no doubt that this "medicine wheel" was carefully prepared and, when it was visited in 1955, it was overgrown with grass but was reverently treasured by Mr. and Mrs. Plume. Because the tall grass could not be cleared away, it was impossible to properly photograph the entire ring.

Evidence that Steel did not vary the general size of the circle, fireplaces or entrance, was obtained when two informants stated that the first twin fireplace tipi ring constructed by Steel was still in existence in the Standoff area. By checking winter counts, the date of this ring was set at 1885.

When found after considerable searching, this tipi ring was seen to be almost identical with the "medicine wheel," with the exception that it did not have the radiating lines. It had the same diameter, the entranceway was the same size, and there was only slight variation in the size of one fireplace. The only major difference was that the fireplaces appeared to be closer to the east entrance by some 3 feet. There was no doubt that this ring was older than the "medicine wheel" as all stones were deeply imbedded in the soil, some being level with the surface.

There was one point about "medicine wheels" upon which all informants were in unanimous agreement: the radiating lines had no religious or symbolical significance. The number "four" is a sacred one among the Blackfoot and often occurs in religious ceremonies and traditional tales. But all agreed that no such symbolism applied here or, if it ever had, all knowledge of it is forgotten. The reply of informant Rides at the Door is typical: "There is no symbolical meaning to the four lines; they just denote his status as a warrior chief."

Upon existing evidence, it would appear that the use of Blackfoot "medicine wheels"

are relatively recent. Informants knew of only two such markers which they could not immediately identify. One was near Red Crow's wheel and was thought to have been much older, while the other was on Sun Dial Hill (Kehoe, 1954, p. 134) and is recorded only through the Geological Survey of 1882-83-84. However, the title, *Onoka-katzi* used by surveyor G. M. Dawson to describe the site, likely means "Elk Shirt" (*Ponoka-sokaxsin*), which was believed by informants to have been the name of a mid-nineteenth century chief of the North Blackfoot.

Because it has been possible only to study "medicine wheels" located on the Blood Reserve and interview informants from the Blackfoot nation, no attempt has been made to carry this study beyond the region of the stated territory. "Medicine wheels," of a type, have been mentioned at Lowry, Mont., by Kehoe, and in the Big Horn Mountains east of Lovell, Wyo., by Mulloy, (1954, pp. 54–55), but further research would be necessary to ascertain if there is any relationship between these, and the relatively recent markers of the Blackfoot. Also field work among the Crow, Assiniboin, Gros Ventre, or other Northern Plains Indians might determine if this custom was familiar to tribes other than the Blackfoot.

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LARGE TERMITE COLLECTION GOES TO SMITHSONIAN

A collection of 230,000 specimens of termites, including 1,286 distinct species of the approximately 2,000 known in the world, has been presented to the Smithsonian Institution by the U. S. Department of Agriculture Forest Insect Research.

Probably the second most valuable of its kind in the world, this collection represents the work of more than 46 years during which Dr. Thomas E. Snyder, retired Department of Agriculture entomologist, has collected termites in the Western Hemisphere and has also obtained many Old World species by exchange and gift. Included in the collection are 943 type specimens. When Dr. Snyder started his collection in 1915 there were only 12 identified species of termites in the Smithsonian collections.

Termites are found over most of the world except the Arctic and Antarctic, Dr. Snyder explains, and probably many kinds still remain unknown. Only those that do damage to human structures have been intensively studied, and extermination of these is now a multimillion-dollar business in the United States. There is always the danger, he says, that some foreign species may invade the country at any time, and therefore means of immediate identification, such as is provided by the Smithsonian collection, may prove invaluable.

Although termites are customarily referred to as "white ants," Dr. Snyder says, there is little, if any, relationship between ants and termites. These two kinds of insects have developed only roughly similar body forms and ways of life by quite independent routes. Termites, he explains, are more nearly related to the roaches, which were among the earliest forms to appear on earth approximately 250,000,000 years ago. The termites, as indicated in fossil deposits, made their first appearance not much more than 50,000,000 years ago and represent a long road from the primitive roaches. They have been termed "social cockroaches." The first ants did not make their appearance until about 30,000,000 years ago. They took on the environment and habits of the termites and, being more advanced organisms, soon drove the older creatures to a wholly subterranean habitat. The ant is much better equipped as a predatory animal.

BOTANY.—*New Umbilicariaceae from the Western Hemisphere, with a key to genera.* GEORGE A. LLANO, Research Studies Institute, Air University, Maxwell Air Force Base, Ala.

The taxonomic portion of this paper is the second concerning the Arctic lichen flora (*6*) and follows the systematic classification first proposed by Scholander (*8*) for the Umbilicariaceae, later revised by Llano (*5*) with the addition of a new genus. Scholander's system, based primarily upon the structure of the apothecia, allows a natural phylogenetic arrangement of species into four well defined genera. A secondary distinction, the presence or absence of a pustulate thallus, serves to distinguish *Lasallia* from *Agyrophora*, as indicated in the following key:

Apothecial disk plane, the whole surface smooth and with a continuous proper margin.
  Thallus pustulate.....*Lasallia* Mérat
  Thallus not pustulate.....*Agyrophora* Nyl.
Apothecial disk plane or convex, surface with a central button and/or fissures, or furrows.
  Apothecial disk plane with sterile central button, or fissure, and/or secondary fissures
    Omphalodiscus Schol.
  Apothecial disk convex, furrowed, with or without a margin.
    Furrows of concentric gyri contained within a continuous proper margin.
      Umbilicaria Hoffm.
    Furrows of radial gyri without any margin.
      Actinogyra Schol.

1. **Agyrophora scholanderii** Llano, sp. nov.

Thallus parvus, 1-2 cm in diam., crassus, monopolyphyllus, marginibus tenuibus infrequentibus laceratis, umbonis eminente, leniter pruinosus in rugis rotundis, supra laevis, mollis, papillis minutissimis, leniter reticulatus-venosus, marginibus integris aut subperforatis, marginibus bruneis obscuris vel atris, subtus niger ebeninus, verrucosus, irregulariter rhizinis longis, rotundis vel planis, irregulariter ramosis, attenuatis, superficies scabra; apothecia pauca vel numerosa, adnata, atra 0.5–1 mm in diam., leiodiscis, marginibus irregularibus, persistentibus; asci 40–45 x 17–24 μ, octospori; paraphyses simplices, apicibus, incrassatis obscurioribus et usque 1.5–2.5 μ inflatis; sporae hyalinae, ellipsoideae, 11–14 x 5–7.7 μ.

ALASKA: lat. 69° N., long. 145° W., Shubelik Mountains, on rocks about 1,300 m alt., near Lake Peters, July–August 1948, P. F. Scholander. Holotype (in author's herbarium). Mount McKinley National Park, on a large erratic in thinly wooded muskeg off road from McKinley Park Station, about 700 m alt., September 1952, G. A. Llano. WASHINGTON STATE: Mason County, summit of Mount Ellinor about 2,000 m alt., July 29, 1912, A. S. Foster no. 2120, ex herb. G. K. Merrill, Farlow Herbarium. The taxon is named in honor of Dr. Peter F. Scholander, professor of zoophysiology, Oslo University, Norway, who, through his studies and field collections, has contributed greatly to our understanding of the lichen family Umbilicariaceae.

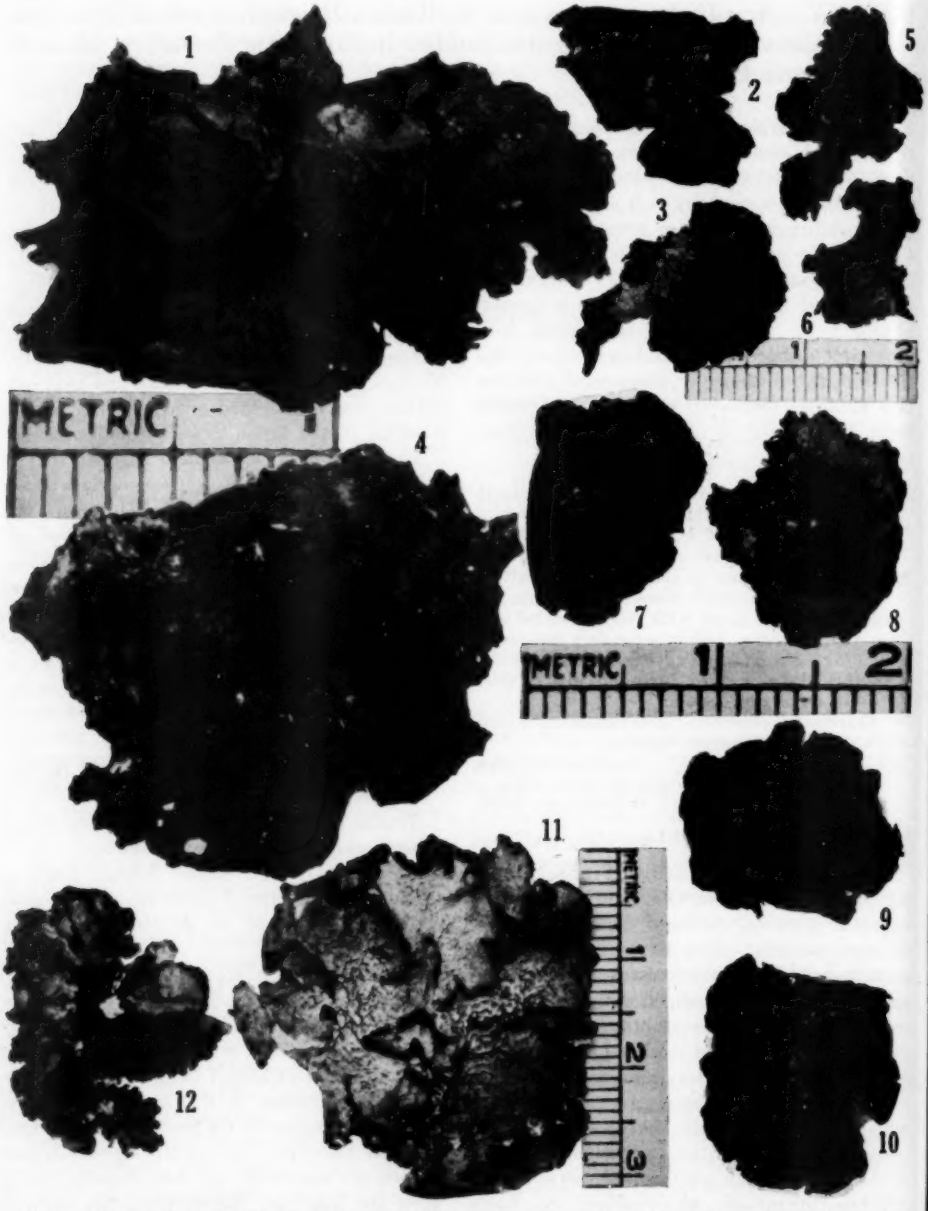
The range of *A. scholanderii* suggests that it is, with *U. angulata* Tuck., a species of the western mountains of North America. However, the former appears to be a plant of the higher interior mountains and of a more arctic distribution; while the latter is typically oceanic and occurs on the Pacific coast from southern California north to the Kenai Peninsula and west to Adak Island. These species, which overlap in the Olympic Mountains in Washington, are the only two Umbilicariaceae endemic to North America.

2. **Umbilicaria aprina** Nyl., in Syn. Lich. 2: 12. 1863. var. **halei** Llano, var. nov.

Thallus minor magnitudine, 1.3 cm in diam., rhizinis minus manifestis vel absentibus.

CANADA: N.W.T., Baffin Island, head of Clyde Fiord, on exposed gneiss boulders, August 26, 1950, M. E. Hale, Jr., no. 450. Holotype (in author's herbarium).

Hale's no. 450 (*3*), was tentatively referred to *U. aprina* Nyl. (*7*), an Abyssinian species later reported from the Ruwenzori Mountains by Frey (*2*). Hasselrot's report (*4*) gave one Norwegian and two Swedish localities, the first recorded occurrences of the species outside of Africa. Comparison of the Scandinavian material with the holotype (Nyl. no. 31742) reveals that Hasselrot's specimens are less densely hirsute then the holotype. Nevertheless, the over all morphological characteristics, especially the conforming shape and color of the rhizinae, substantiates Hasselrot's decision. Hale's specimens are homogeneous and differ in the following details from the African and European material:



FIGS. 1–12.—1–3, *Agyrophora scholanderii* Llano, sp. nov., upper (1) and two lower (2, 3) surfaces of holotype; 4–6, *A. sholanderii*, upper (4) and two lower (5, 6) surfaces of Mount McKinley sample; 7–10, *Umbilicaria aprina* Nyl., var. *halei* Llano, var. nov., upper (7) and three lower (8–10) surfaces of holotype; 11, 12, *Ophalodiscus decussatus* (Vill.) Schol. var. *tortuosus* Llano, var. nov., upper (11) and lower (12) surfaces of holotype. (Photo by R. K. Stockard).

They are dimunitive, spherical, and slate to gray black; one-third to three-fourths of the inner lower surface is covered by a circular, sooty, rarely mottled patch terminating in black flecks, and contrast sharply with the fuscous, pruina-tinged outer lower rim. Rhizinae are sparse to absent, and are confined to the fuscous zone. Otherwise, they are typical. Strap-shaped, bifurcate rhizinae extend outward, mainly from the thallus periphery, as tongue-like extensions. Lacking more definitive or fertile material, the original determination for Hale's no. 450 is maintained. However, the singular features cited justify a variety designation. The name honors the collector, Dr. Mason Hale, Jr., for the first record of *U. aprina* Nyl., from the Arctic and New World.

3. **Omphalodiscus decussatus** (Vill.) Schol., in Nyt Mag. Naturvid. 75: 23. 1934. var. **tortuosus** Llano, var. nov.

Thallus 2–5 cm in diam., irregularis, rigidus, mono-polyphyllus, densus, umbo obscurus, crasse verrucosus, superficies superior subverrucosa vel laevis, rugi absentes vel molles, marginibus laciniatis; subtus laevis, ater, raro bruneus, raro lacunis. Apothecia non visa.

ANTARCTICA: MacRobertson Land, A.N.A.R.E. Base Mawson (lat. 67° 36′ 21″ S., long. 62° 52′ 48″ E.). "Uncommon and occurring as a large patch covering an area 100 x 200 yards on a northwest facing slope." Leg. R. O. Summers, January 1955.

Through the courtesy of the director of the Antarctic Division, Department of External Affairs, Melbourne, Australia, exsiccatae material was obtained of four Antarctic Umbilicariaceae. The collections made by two members of the 1954–1955 A.N.A.R. Expedition, David P. Sweetensen and Dr. R. O. Summers, included the following species: *Omphalodiscus spongiosus* (Dodge & Baker) Llano, *O. decussatus* (Vill.) Schol., and *O. decussatus* (Vill.) Schol. var. *cerebriformis* (Dodge & Baker) (*1*) Llano, and a homogeneous number of *O. decussatus* var. *tortuosus* Llano.

The writer gratefully acknowledges the assistance of Mrs. Kenneth R. Whiting with the Latin diagnosis; and of Dr. E. H. Walker, of the Smithsonian Institution, whose valuable criticisms in the preparation of this paper are much appreciated. M/Sgt. J. L. Pearce, NCOIC, and M/Sgt. R. K. Stockard, special photographer, Maxwell Air Force Base, Alabama, provided the illustrations.

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I often say that if you can measure that of which you speak, and can express it by a number, you know something of your subject; but if you cannot measure it, your knowledge is meagre and unsatisfactory.—LORD KELVIN.

ENTOMOLOGY.—*Redescriptions of four species of neotropical* Culicoides *of the* debilipalpis *group (Diptera: Heleidae).*

WILLIS W. WIRTH[1] and FRANKLIN S. BLANTON.[2] (Communicated by Alan Stone.)

In the course of our taxonomic study of the Panama *Culicoides* of the very difficult *debilipalpis* group, we have restudied type material of several non-Panamanian species for purposes of comparison. We feel that the study of certain characters which were not utilized when these species were described a number of years ago is essential for recognition of species in this group. We therefore take this opportunity to offer redescriptions and figures of four of these species.

We are deeply grateful to Paul Freeman and the trustees of the British Museum (Natural History) for the opportunity to study type material (see discussion under *germanus*) of *dasyophrus* Macfie and *germanus* Macfie from British Guiana. To Irving Fox of the University of Puerto Rico we are equally appreciative of his kindness in lending us the holotypes of *trilineatus* Fox and *hoffmani* Fox from the West Indies.

There are several terms the exact definitions of which are essential to the descriptions. Wing length is measured from the basal arculus to the wing tip; we use the Tillyard modification of the Comstock-Needham terminology of wing veins, thus the two discal forks emit the branches M_1 and M_2 on the anterior fork and M_{3+4} and Cu_1 on the posterior fork. The antennal ratio is the value obtained by dividing the combined lengths of the last five segments by the combined lengths of the preceding eight. The measurement of the length of the spermatheca includes the sclerotized portion of the duct. Our measurements are of single specimens unless followed by values in parentheses in which case the values are "mean (minimum-maximum, n = number of measurements)."

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Culicoides dasyophrus Macfie

Fig. 1

Culicoides dasyophrus Macfie, 1940, Ent. Monthly Mag. **76:** 27 (male, female; British Guiana); Ortiz, 1952, Acta Cient. Venezolana **3:** 126 (Amazonas Terr., Venezuela; female redescribed; fig. antenna, spermatheca).

Characters of female.—Length of wing 0.74 (0.69–0.76, n = 4) mm.

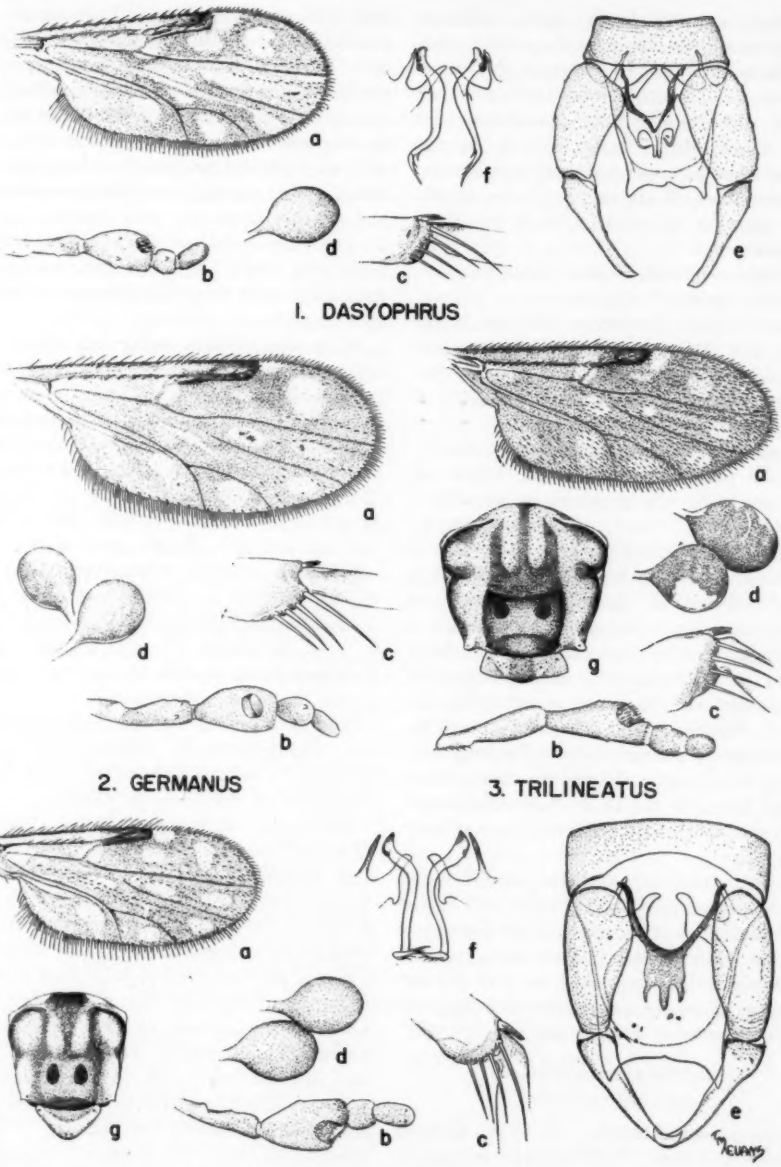
Head: Eyes narrowly separated above, with long interfacetal hairs. Antenna with flagellar segments in proportion of 15:10:10:10:10:10: 10:10:15:18:19:20:33, antennal ratio 1.23; distal sensory tufts present on segments III, VII-X. Palpal segments in proportion of 5:14:14:6:7, third segment swollen, 1.65 times as long as greatest breadth, with a broad, shallow, sensory pit. Mandible with 14 teeth.

Thorax: Mesonotum dark brown with a pair of large, elongated submedian yellowish spots and a pair of obscure, dark-brown vittae laterad of these; scutellum brown in middle, paler on sides. Legs dark brown, fore and mid femur with subapical, all tibiae with subbasal and hind tibia with apical, narrow pale rings; hind tibial comb with 4 spines, the one next to the spur longest.

Wing: Pattern as figured, pale spots rather small and not very distinct; poststigmatic pale spots in cell R_5 more or less fused, the posterior one located slightly proximad of the anterior one; distal pale spot in cell R_5 small, only one small pale spot in distal part of anal cell and one pale spot in distal part of cell M_2; indistinct pale spot in front of mediocubital fork; macrotrichia sparse on distal third of wing; costa extending to 0.61 of distance to wing tip. Halter whitish.

Abdomen: Dark brown, cerci yellowish; spermatheca one, pyriform, measuring 0.044 by 0.033 mm, the duct narrow and sclerotized for a considerable distance.

Male genitalia.—Ninth sternum without caudomedian excavation, the posterior membrane not spiculate; ninth tergum long and tapering, the apicolateral processes short and blunt. Basistyle with ventral root foot-shaped, the caudal heel not long, dorsal root longer and slender; dististyle



FIGS. 1–4.—1, *Culicoides dasyophrus* (paratype from New River, British Guiana); 2, *Culicoides germanus* (presumed type, New River, British Guiana); 3, *Culicoides trilineatus* (from St. Croix, Virgin Islands); 4, *Culicoides hoffmani* (Puerto Rico; ♂ from Carolina, ♀ from Guyanilla). (*a*, female wing; *b*, female palpus; *c*, apex of hind tibia showing spur and comb of tibial spines, female; *d*, female spermathecae; *e*, male genitalia, parameres omitted; *f*, male parameres; *g*, thoracic color pattern, female. Drawings by Thomas M. Evans.)

nearly straight, with slender apex. Aedeagus very short and broad, basal arch more than half as high as total length of aedeagus, the transverse anteromesal sclerotized membrane rounded, apex with a short blunt inner sclerotized point enclosed by a short, bluntly conical, hyaline lobe. Parameres each with knobbed base, slender, sinuate stem without apparent ventral lobe and slender, tapering tip with 4 or 5 subapical, lateral barbs.

Distribution.—British Guiana, Venezuela.

Specimens examined.—As follows:

BRITISH GUIANA: New River, 750 feet, March 20, 1938, C. A. Hudson, 1 male, 7 females (paratypes of *dasyophrus*).

VENEZUELA: Amazonas Territory, 1951, P. Anduze, 7 females.

Discussion.—The redescription and illustration of the paratypes from British Guiana are made possible by the generous cooperation of Paul Freeman and the trustees of the British Museum (Natural History), who kindly lent us the material for study. We are also indebted to I. Ortiz for the gift of Venezuela specimens from the same collection upon which he reported in 1952. We are thus able to confirm Ortiz's determination of this species by direct comparison with type material. Barbosa's record (1947, An. Soc. Biol. Pernambuco *7:* 14) and figure of the male genitalia of *dasyophrus* from Panama, however, are erroneous, and specimens from Barro Colorado Island in the U. S. National Museum labeled *dasyophrus* by Barbosa are actually *castillae* Fox.

The long distal five antennal segments, the presence of sensoria on segments III, VII–X, the short, broad, third palpal segment, the prominent mesonotal pattern, the obscure wing pattern with only one distal spot each in anal cell and cell M_2, and the pale apex of the hind tibia will serve to characterize *dasyophrus*.

Culicoides germanus Macfie

Fig. 2

Culicoides germanus Macfie, 1940, Ent. Monthly Mag. **76:** 27 (female; British Guiana).

Characters of female.—Length of wing 0.79 mm. The head was not dissected from the body and can be seen only in side view. Eye apparently hairy above, bare on lower portion. Antenna with flagellar segments in proportion of 18:15; 15:19:19:19:19:19:19:19:20:19:41, antennal ratio 0.80, distal sensory tufts present on segments III, VII-X. Palpal segments in proportion of 6:18:20:6:7, third segment distinctly swollen, about twice as long as greatest breadth, with a broad, shallow sensory pit. Mandible in wrong position to count teeth. Mesonotum dark brown, without apparent pattern (but may be due to being a slide mount); scutellum, postscutellum, and pleuron uniformly dark brown. Legs dark brown, femora entirely dark, tibiae with subbasal pale rings, hind tibia with apex broadly pale, comb with four spines, the second from the spur longest.

Wing with pattern as figured, second radial cell rather long and narrow, costa extending to 0.60 of distance to wing tip. The three pale spots in cell R_5 arranged in a triangle, the two poststigmatic pale spots in cell R_5 small and well separated, the posterior one located far proximad of the anterior one, distal spot in cell R_5 rounded except on distal side. Two pale spots in cell M_1, only one pale spot each in apices of anal cell and cell M_2, no pale spot present anterior to mediocubital fork but an indistinct pale spot present behind base of medial fork. Macrotrichia sparse, in rows, in apices of cells, R_5, M_1, and M_2. Halter pressed against thorax, not visible in profile, its color undetermined.

Abdomen dark brown, cerci pale; spermathecae two, slightly unequal, collapsed and impossible to measure, apparently pyriform, with the ducts sclerotized a considerable distance.

Specimens examined.—Macfie (1940, Ent. Monthly Mag. **76:** 27–28) described this species and *debilipalpis* var. *glabrior* each from a single female from New River, British Guiana, collected in February and March 1938 by C. A. Hudson. In response to our inquiry regarding the types of *germanus* and *glabrior* Paul Freeman of the British Museum (Natural History) stated that the only material of these species which he could find in the Macfie collection in the Museum was one slide on which were mounted two females, without locality data, but bearing only the label in Macfie's handwriting, "*Culicoides/ debilipalpis* Lz. / v. *glabrior* / ♀ (large specimen) / *C. germanus* / ♀". After careful study we can only conclude that these specimens are in fact the types of *glabrior* and *germanus*, and the smaller specimen is here redescribed as the presumed type of *germanus*. The larger specimen will be redescribed elsewhere as the presumed

type of *glabrior*. To our knowledge *germanus* is still known only from the type specimen.

Discussion.—*Culicoides germanus* is very closely related to *debilipalpis* Lutz and *hoffmani* Fox but can be distinguished by the very hairy eyes, the presence of sensoria on the seventh antennal segment, the entirely dark femora, and the greater separation of the two proximal pale spots in cell R_5.

The description and figures given under the name of *germanus* by Wirth (1955, Proc. Ent. Soc. Washington **57:** 111) from Guatemala specimens are based on misidentifications of *gabaldoni* Ortiz. *Culicoides insinuatus* Ortiz and Leon, 1955, from Ecuador is very similar to *germanus*, with similar wing pattern and femora without subapical pale rings, but *insinuatus* differs in having a very deep sensory pit with a small pore on the third palpal segment.

Culicoides trilineatus Fox

Fig. 3

Culicoides trilineatus Fox, 1946, Ann. Ent. Soc. Amer. **39:** 250 (female; St. Thomas, Virgin Islands; biting man; fig. mesonotum, wing); Fox, 1949, Bull. Brooklyn Ent. Soc. **44:** 30 (male, female; Puerto Rico; reared, tree hole; fig. palpus, spermathecae, male aedeagus, parameres).

Characters of female.—Length of wing 0.97 (0.92–1.02, n = 7) mm.

Head: Eyes broadly separated, bare. Antenna with flagellar segments in proportion of 19:15: 15:17:17:15:15:15:17:18:19:20:33, antennal ratio 0.86 (0.82–0.94, n = 3); distal sensory tufts present on segments III, sometimes on V, always on VI-X. Palpal segments in proportion of 13:24:30:10:12, third segment slightly swollen toward extreme tip, 2.6 (2.3–3.0, n = 7) times as long as greatest breadth, with a shallow, small, sensory pit. Mandible with 18 (17–18, n = 7) teeth.

Thorax: Mesonotum grayish brown, with a prominent dark-brown pattern consisting of three longitudinal lines connected posteriorly by a transverse line just in front of prescutellar depression, the two lateral lines continued caudad along sides of this depression and extending from humeral pits to sides of scutellum; lateral margins dark brown with mesal extensions anteriorly to humeral pits and posteriorly along mesonotal suture. Scutellum dark brown, ends slightly paler; postscutellum and pleuron dark brown. Legs brown, fore and mid knees dark, with narrow pale rings on each side of joint, hind tibia with pale band at base and apex; hind tibial comb with 4 (n = 7) spines, the second from the spur longest.

Wing: Pattern as figured, a double poststigmatic pale spot in cell R_5, the posterior portion extending slightly proximad of the anterior part; distal pale spot in cell R_5 small, transverse; proximal spot in cell M_1 very small, one small pale spot in apex of anal cell, no pale spot in front of mediocubital fork but a pale line connecting pale spot behind medial fork to a distinct subapical, second spot in distal portion of cell M_2. Macrotrichia very long and abundant, extending to base of wing in anal and medial cells; costa extending to 0.57 of distance to wing tip. Halter brownish, the flat end paler.

Abdomen: Dark brown; spermathecae two, pyriform, subequal, measuring 0.056 by 0.039 mm, the bases of the ducts sclerotized a short distance.

Distribution.—St. Thomas (type locality); Puerto Rico, Barbados, St. Croix.

Specimens examined.—60 females from:

BARBADOS: 1, no. 861, A. J. Jennings.

VIRGIN ISLANDS: St. Croix—3, Diamond School, September 1938; 1, Fountain, valley of jungle and stream 1 mile from seacoast, May 1935; 15, Salt River, September 1938; 11, Tagus Pond, May 1936; all collected by H. A. Beatty. St. Thomas—Red Hook, September 11, 1937, biting in the afternoon (holotype of *trilineatus* lent from Univ. Puerto Rico collection through the courtesy of Irving Fox).

Discussion.—This species is obviously closely related to *debilipalpis* Lutz but can be readily separated by its prominent mesonotal pattern, its hairier wings, with reduced pale spot at base of cell M_1, no pale spot before mediocubital fork, the third palpal segment shaped differently, and the greater number of proximal antennal segments with sensoria.

Culicoides hoffmani Fox

Fig. 4

Culicoides hoffmani Fox, 1946, Ann. Ent. Soc. Amer. **39:** 251 (female; Cumuto Village, Trinidad; biting; fig. mesonotum, wing); Fox, 1949, Bull. Brooklyn Ent. Soc. **44:** 29 (male, female; Puerto Rico; reared, tree hole; fig. palpus, spermathecae, male aedeagus, parameres).

Characters of female.—Length of wing 0.76 (0.73–0.86, n = 9) mm.

Head: Eyes separated, the line of separation broad above but narrowed below, eye with short interfacetal hairs. Antenna with flagellar segments in proportion of 14:11:13:15:15:14:14:15:14:14:15:15:25, antennal ratio 0.79 (0.75–0.84, n = 3); distal sensory tufts present on segments III, VIII-X. Palpal segments in proportion of 6:11:19:6:7, third segment very short and swollen, 1.6 (1.5–1.7, n = 9) times as long as greatest breadth, with a moderately large and deep sensory pit. Mandible with 14 (13–15, n = 5) teeth.

Thorax: Mesonotum pruinose brown with pattern as figured, consisting essentially of a sublateral pair of darker brown patches, widest at midlength; scutellum, postscutellum and pleuron dark brown. Legs dark brown; fore and mid femora with subapical, all tibiae with subbasal and hind tibia with apical, narrow pale rings; hind tibial comb with 4 (n = 9) spines, the one nearest the spur longest.

Wing: Pattern as figured; two slightly separated, poststigmatic pale spots in cell R_5, the posterior one lying only slightly proximad of the anterior one; distal pale spot in cell R_5 moderately large, rounded; two pale spots in cell M_1; one pale spot each in apices of cells M_2, M_4 and anal cell, the one in anal cell failing by its own diameter to meet wing margin; a pale spot lying in front of mediocubital fork and another pale spot lying behind medial fork; macrotrichia sparse on distal third of wing, none in anal cell, cell M_4 or base of cell M_2; costa extending to 0.59 (0.57 – 0.62, n = 9) of distance to wing tip. Second radial cell well developed. Halter brown, the flat end of knob whitish.

Abdomen: blackish, cerci pale; spermathecae two, pyriform, slightly unequal, measuring 0.048 by 0.034 and 0.043 by 0.031 mm.

Male genitalia.—Ninth sternum with very broad and shallow caudomedian excavation, the posterior membrane bare; ninth tergum long with large, triangular, apicolateral processes. Basistyle with ventral root large and foot-shaped, dorsal root slender; dististyle slender and nearly straight with hooked apex. Aedeagus with basal arch rounded caudad, extending to slightly more than half of total length, basal arms slender and curved; distal apex broadly expanded with three pointed lobes of subequal lengths. Parameres each with knobbed base, stem abruptly bent near base, very slender, mid-portion sinuate, no trace of ventral lobe, apex pointed with lateral fringe of fine hairs.

Distribution.—Trinidad, Puerto Rico.

Specimens examined.—As follows:

TRINIDAD: Cumuto Village, June 11, 1941, biting, 1 female (holotype from University of Puerto Rico collection). Cumaca, June 16, 1954, Aitken and Downs, biting man, 2 females. Macqueripe, October 20, 1955, T. Aitken, light trap, 1 female. Melajo Forest, Sangre Grande, October 19, 1955, T. Aitken, biting man, 1 female. Port of Spain, June 1953, U. S. Army, 25 Med. Det., light trap, 2 males, 3 females. St. Pats, Arima, December 31, 1954. W. G. Downs, 1 female; December 10, 1954, T. Aitken, 4 females.

PUERTO RICO: Carolina, September 20, 1949, I. Fox, reared from tree hole, 3 males. Guyanilla, March 1949, I. Fox, reared from tree hole, 2 females. Mamayes, November 5, 1948, I. Fox, treehole, 1 male, 1 female.

VIRGIN ISLANDS: St. Croix, August 1935, H. A. Beatty, 6 females.

Discussion.—*Culicoides debilipalpis* Lutz, which is also common in Trinidad and the Antilles, can be distinguished by its slightly larger size (wing 0.80 mm long), longer, more slender palpus, the third segment 2.2 times as long as broad, with a small, deep pit, the second segment subequal in length to the third; wing hairier, macrotrichia extending in two lines to base of cell M_2 and numerous in anal cell, and the two post-stigmatic spots in cell R_5 more closely approximated and the posterior one located more distinctly proximad of the anterior one.

Culicoides equatoriensis Barbosa from Ecuador resembles *hoffmani* in wing markings, in restriction of the macrotrichia to the distal half of the wing, and in the possession of a broad shallow palpal pit but, according to the original description, differs in having the third palpal segment slightly longer, the eyes bare and contiguous, and subapical pale rings on all three pairs of femora.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY

1403D MEETING, JANUARY 14, 1955

The retiring president's address on *Solar influences on cosmic-ray variation* was delivered by SCOTT E. FORBUSH.

For almost 22 years, or two full sunspot cycles, the Carnegie Institution has carried on a program of continuous measurement and recording of total cosmic-ray ionization on a world-wide basis and the accumulated results of this program and their extensive statistical analysis was presented.

The instruments used are ponderously shielded but delicate and highly sensitive, high-pressure ionization chambers, of 20 liters volume and filled with argon at 50 atmospheres. The measuring device is a Lindemann electrometer, photographically recorded, and so connected that most of the ionization current is balanced out against the current produced in a subsidiary chamber by a constant uranium source. These instruments have been installed in, among other places, Cheltenham, Md.; Godhavn, Greenland; Teoloyucan, Mexico; Christ Church, New Zealand; and Huancayo, Peru. This wide geographic distribution serves to cover as many geomagnetic latitudes as possible. An extensive series of slides illustrating the changes in ionization current and its correlation geographically and with solar phenomena was presented.

There seem to be at least four types of variation detected in the ionization currents: (1) Sudden, rare, but quite large, increases, associated probably with low energy heavy particles from the sun; (2) world-wide decreases associated with magnetic storms; (3) a quasiperiodic variation of 27-day period—the period of rotation of the sun—that lasts only for a few periods and disappears, like the sun-spots themselves; and (4) an 11-year variation correlated with the sunspot numbers. The four variations are all clearly associated with solar phenomena, and the conclusion reached is that the sun is responsible, directly or indirectly, for them all.

CHESTER H. PAGE, National Bureau of Standards, contributed an informal communication on a widely known puzzle: the so-called "Odd Ball Problem." "Given 13 coins, or other objects, either identical *or* with just one of them either light *or* heavy, how decide with only three weighings on a balance, which one, if any, is bad and in which sense?"

It will be noted that each weighing provides one of three possible answers: Pan A heavy, balanced, Pan A light. What is needed is a weighing schedule showing which coins go in which pans at each weighing. To get it, assign the number 1 to "Pan A heavy," 0 to a "balance," and -1 to "Pan A light." We also assign each coin a number, including zero: the zeroth coin is 000, the first coin is 001, etc. on the base of enumeration 3, with the added proviso that we use the digits 1, 0 and -1. Thus the second coin is (3–1), or numerically $01\bar{1}$, the third 010, the fifth $1\bar{1}\bar{1}$, etc. These numbers are now to be written in a column, omitting zero and 13, and the column of first digits is the required weighing schedule, with 1 meaning the coin goes in Pan A, $\bar{1}$ in pan B, 0 in neither. To get four coins in each pan, however, evidently the signs of four coins have to be changed, in such fashion that each column shall contain as many plus 1's as minus 1's. This change can be made in any of seven ways, and when carried out, the three columns of digits give the three weighing schedules. The result of each then gives a number, and the three weighings together give the three digit number of the coin that is heavy, or if it comes out negative, light. If all weighings balance, 000, all coins are good.

To weigh 13 coins the fulcrum of the balance must be shifted so that the arms are in the ratio 5:4, and the thirteenth coin put always in the short arm with four others. The same schedule applies as before, and the behaviour of the balance gives the answer, in the same numerical code. (*Secretary's abstract.*)

1404TH MEETING, JANUARY 28, 1955

MARK KAC of Cornell University, spoke on *The emergence of statistical thought.*

There have been two approaches to statistical methods in the past: as a necessary evil on the one hand and as a logical and scientific necessity on the other. The discovery of the Mendelian laws represent one of the rare successes of the first approach; in the other branches of the exact sciences a hypothesized model acts as a guide to the data to be taken.

A series of horrible examples will show the dangers of applying statistical methods without

due care. Consider the mania for "objective tests." Suppose a man answers 60 out of 100 yes-or-no questions correctly. Is the result meaningful? A monkey and a coin have a 34-percent chance of doing as well. Consider the apparent cycles in the population of rabbits, or lemmings or other animals. A plot shows that the average time between peaks of population is 3½ years, with a 20-percent reliability. But a plot of acknowledgedly random numbers also shows a figure of 3.1 years with a 20-percent reliability. (One trouble here is admittedly psychological and semantic: the work random connotes to the statistically untrained a phenomenon of no observable regularity.) The work of Udne Yule showed that the use of a moving average on the "business cycle" curve introduces spurious periodic behavior, just as a band pass filter does to a noise spectrum.

Intuition is not a safe guide. For example, in the heads-or-tails game, if one throw is made every second, and the game is played for a year, it is not "incredible" that one player was behind all but 13½ hours, but merely a 5 percent chance. The chance of being behind all but 32 minutes is one percent. Again, a false estimate of the effects of a particular procedure may be disastrous, as is the "optional stopping" used in the ESP experiments at Duke. Dropping out "those who cease to do well" may change the probabilities, not by a few percent, but by a factor of four or five.

The logical difficulties inherent in Quantum Mechanics were, and are, of no mean order. For a most uncomfortably long time logic showed that the theory was untenable, but its agreement with experiment was unshakable. The Ehrenfest model of 2R balls in two boxes, properly handled, resolves the Poincare paradox and others, by showing that although the probability of recurrence of the initial configuration after an infinite time is unity, the probable time taken to achieve this recurrence is in fact so nearly infinite that the recurrence is practically impossible. Mathematically, if $P(s)$ is the probability that after s steps we return to the initial configuration with all the balls in one box, then $\sum_2^\infty P(s) = 1$, but $\sum_2^\infty sP(s) = 2^{2R}$.

Finally, can the statistical approach be of use in pure mathematics? A consideration of the Descartes "Rule of Signs" for determining the number of positive roots of an equation of nth degree shows that it can. Statistically the number of positive roots should be about $(1/\pi) \log n.$, a smaller quantity in general than the number of sign changes. Multiplying the entire polynomial by $(1 + t + t^2 + \cdots + t^n)$ reduces the sign changes to $\sqrt{n}$ which is much nearer the expected value. "We ask a little less, we get a little more."

"To use statistics best, immerse the problem at hand in an ensemble of statistical data and deal with it rigorously." Three great discoveries of basic importance to science are Logic by the Greeks, the Experimental Method by Post-Renaissance Western Europe, and Statistical Thought by the Twentiety Century. (*Secretary's abstract.*)

1405TH MEETING, FEBRUARY 11, 1955

The 1405th meeting of the Society was called to order at 8:15 p.m., by the Recording Secretary in the absence of all officers senior to him in authority. It was reported by the Chairman of the Communications Committee that the Speaker was snowed in somewhere along Route 1.

After announcement of the next speaker, there was a call for informal communications, and the Society took a recess for 15 minutes to await a larger audience.

The Society reconvened at 8:30, Mr. Tuckerman spoke briefly on Hexaflexagons, and Mr. Montroll gave a short talk on *Cayley trees* and their applications (when generalized to include closed figures) to governmental and other executive organizations.

Methods for the calculation of the number of trees of a given type, for selection of the type of tree (i.e., organizations best suited to a given job) and for their applications were all indicated. For example, a group doing operations analysis should have many cross-connections, a dictatorship is a "classic" branching tree, a system of checks and balances is a triangle.

Further discussion of "Tuckerman trees" by their author, a reference to a system of shorthand for use in organic chemistry by the Recording Secretary, and a note on Quaternions from the floor ended proceedings.

1406TH MEETING, FEBRUARY 25, 1955

ROBERT G. BRECKENRIDGE, of the National Bureau of Standards, spoke on *Gray tin*. There are many substances that exist in two or more allotropic forms (familiar examples are carbon, sulfur, and phosphorus), but tin seems to be the

most puzzling and romantic of them all. All gray tin, of which a specimen was shown, quite possibly originates from one original crystallization, a seed from which seems to be needed to initiate the spontaneous change from the ordinary metal that may occur at temperatures below 13.2° C. Gray tin is the so-called alpha phase of tin, with a cubic lattice, of the diamond type, lattice constant 6.4912 A, and density of 5.763. The ordinary metal, the beta phase, stable above 13.2° C, has a density of 7.281. Gray tin is a semiconductor, a gray amorphous powder of very little strength, and bearing no resemblance to the white metallic phase. It is no wonder that the term tin disease, or tin plague, has been applied to the transformation.

The conditions for transformation are not well understood. Temperatures below 13.2° are necessary but not sufficient. After much fruitless work, it was necessary to procure a seed crystal from Cornell, which laboratory had obtained theirs from the Dutch worker Ernest Cohen, who had had some from an 1868 chance crystallization of a shipment in St. Petersburg Harbor. The retransition back to metallic tin takes place easily above the transition temperature, but is apparently not complete until the metal is actually melted. Some specimens have evidently retained their seeding power for many decades. The low-temperature transition is accelerated by Al and Mg ions, among others, but is inhibited by Bi, and to some extent by Pb. Contact with electrolytes has no influence on the transformation at the National Bureau of Standards, but is frequently reported to have some elsewhere! Germanium is contradictorily reported sometimes as favoring the change, sometimes as of no effect. Work using gray and white tin as electrodes in the electrochemical cell lead to anomalous results. Instead of the ½ millivolt at zero degrees predicted from specific heat measurement, falling to zero linearly as the temperatures rises to the transition point, the EMF is approximately constant at 10 millivolts (for divalent ions in solution) falling abruptly to zero at the transition point. This result has thus far remained unpublished, being not understood. Independent measurements of the heat capacity, however, yield a normal value.

Measurements of energy change based on a first order reaction equation yield a ΔE of 180 calories in the white to gray direction, but 2,300 calories in the reverse. Particle size appears to have an important effect here. On successively transforming and retransforming many times, the gray form reduces to a micro-fine powder, on which consistent values, less than 2,300, but still much higher than 180 calories are obtained.

Determined effects to produce gray tin in a form suitable for electrical measurements finally succeeded, using a technique of depositing an electroplated film on a suitable substrate, transforming the film to the alpha modification and then removing the substrate. Another technique, transforming thin single crystals was also successful. Measurements of the Hall effect and of conductivity with these specimens show an abnormally high mobility: about 28,000 while the best Ge is only 3,000–4,000. The material shows photoconductivity well into the infra red. The Hall coefficient is a function of the magnetic field, unlike Ge and other well-behaved materials, and the $T^{3/2}$ power law does not hold. Other workers have found it to be obeyed. This difficult material is indeed a semi-conductor, but all its properties are very unusual and lie in a range where they are most difficult to measure and where the usual approximations and assumptions do not hold. (*Secretary's abstract.*)

1407TH MEETING, MARCH 11, 1955

JAMES D. HARDY, of the Naval Air Development Center, Johnsville, Pa., spoke on *Pain and tissue damage*. Concerning the phenomenon of pain as a whole there is little agreement among either philosophers or laity. There are moral aspects, psychological aspects, physical aspects and sociological aspects. In order to isolate an objective element of the problem, the studies presented were strictly limited to the sensation or the "experience" of pain. Some authorities state that even this cannot be done and that meaningful results can be obtained only by treating pain "holistically."

The technique employs a projection light as a source of heat, with a shutter to regulate the time of exposure, shining onto the blackened skin of the subject. The intensity of the light is increased during three second exposures until the threshold of pain is reached: this threshold being judged by the subject. It turns out that this technique is quite a satisfactory one: all subjects of all ages and both sexes responding to the same threshold with only a 4 percent standard deviation. "Everybody is equally sensitive to pain" is the conclusion for this limited type of stimulus. Even though limited, it is a conclusion quite contrary to the

usual doctor's belief. However, the ordinary physician is not measuring a pain threshold, but observing a human being as a whole in a far more complex situation

"Are two pains worse than one?" Plotting log of the exposed area against intensity of stimulus it is found that the threshold of feeling falls as the area increases, but the threshold of pain does not. Pain does not exhibit "area summation." That is a unique phenomenon in sensory psychology. The threshold can be raised by 10 to 50% by reading, hypnosis, distractions like loud bell-ringing, but nothing lowers it.

Extensive data show that pain occurs when the skin temperature reaches 45° C through a wide range of initial conditions. The input required to produce pain is greater when the skin is cold initially, but the criterion for pain remains 45°. Other materials beside the cooperative human subject were employed as well, among them a paraplegic case, bats' tails, guinea pigs' skin, and non-English-speaking Eskimos. The data were satisfactorily consistent.

There are three different sensations here: cold, warmth, and pain, but only one set of nerve endings. This is a morphological puzzle for which there seems to be no current explanation.

Data taken by Henriquez and Morris were quoted to show that tissue damage was dependent upon the product of time and temperature. In contrast, Dr. Hary's results show that pain is an indication of the rate of damage. It is well known there is no one-to-one relation between pain and integrated tissue damage, as is shown by severely wounded cases during the last war.

The scale of pain, measured in "dols" was explained. There seem to be subjectively 22 perceptible steps from initiation to saturation of the sensation. Two parts are called a dol, and there are thus 11 dols in the scale. The dols go up with the skin temperature.

When there has been previous tissue damage, even though fairly mild, as in a case of sunburn, the threshold for pain may be lowered quite markedly, even down to 35°. In the normal skin the rate of tissue repair can keep pace with the damage up to 45°, but if there is previous unrepaired damage, as in the sunburn, then the repair mechanisms are overloaded and pain results. 45° is the temperature at which human proteins are inactivated. Some animals, e.g., birds, have higher body temperatures, and it would be interesting to determine if their threshold is higher too.

A wide-ranging discussion elicited some further points of interest. For example, cold blooded animals suffer irreversible changes at 35° or less, it takes approximately 100,000 calories per mol to inactivate a protein, a sustained pain of neurologic origin is not shut off by cutting the nerves to the part in which the pain is felt. Laboratory pain is different from pain in the sickroom and caution should be used in applying the results of this study, but in general pain and rate of tissue damage are strongly correlated. (*Secretary's abstract.*)

1408TH MEETING, MARCH 25, 1955

This meeting of the Society was the occasion of the twenty-fourth Joseph Henry Lecture on *Tritium in nature*, by WILLARD F. LIBBY, of the U. S. Atomic Energy Commission. The lecture has been published in this JOURNAL **45**: 301–314. 1955.

NOTES AND NEWS

THE SCIENCE TEACHER REPLACEMENT PROJECT

On March 15 and 16, 1956, the Joint Board for Science Education of the Washington Academy of Sciences and the D. C. Council of Engineering and Architectural Societies sponsored an unusual teacher replacement program in the junior and senior high schools in the Greater Washington area to free teachers to attend meetings of the National Science Teachers Association in Washington and to visit local laboratories. On these days scientists and engineers took over classes in the schools so that students, scientists, and teachers would learn something of one another's interests and problems. In all, 100 schools and 320 teachers from the District of Columbia, Prince Georges and Montgomery Counties in Maryland, and Arlington and Fairfax Counties and Alexandria and Falls Church in Virginia took an active part; and 1,350 scientists volunteered to serve as substitute teachers and many more expressed a willingness to serve if needed.

The plans for this program were initiated by

the Joint Board early in October, when the superintendents of various schools in this area were contacted to establish their willingness to participate in such a program. The schools cooperated directly by supplying the names of teachers desiring replacements along with their subjects and class schedules. The detailed plans for the recruiting of scientists and engineers were carried out primarily by a liaison committee composed of scientists in the Washington area. These plans started with a meeting on December 19, at which chairmen were chosen for the various scientific fields such as biology, chemistry, physics, and general science. It was the task of each of these chairmen to choose representatives in each of the universities, and in government and industrial laboratories in his particular field, who would be responsible for enlisting individual scientists and engineers in his laboratory to serve as teacher replacements. The directors of these organizations and laboratories and the presidents of various technical societies were also approached for their cooperation in this project. Many technical societies appointed individual members who were active in publicity and enlisting scientists and engineers from their respective societies.

The office of the science supervisor of the D. C. Public Schools at Woodrow Wilson High School served as headquarters for the liaison committee during this period. One full-time secretary and another part-time secretary were provided for this office by Science Service. These secretaries did large amounts of the typing, answered the telephones, and participated in all phases of the work. After February 1, scientists, school supervisors, and teachers converged on the office of the science supervisor to help with the assignment task. The actual assignment task was one of primarily matching scientist cards with teacher cards so that the indicated times at which scientists were available fitted with the subjects and periods of the teacher's classes. Insofar as possible attempts were made to place scientists in or nearby their indicated schools of preference. Throughout all these proceedings the advice of the science supervisor with regard to schools, teachers, and related subjects was freely drawn upon.

When once the assignments were completed, large amounts of correspondence became necessary. This was handled by secretaries and teachers in the office of the science supervisor, outside laboratories, schools, the Joint Board, and elsewhere. Because of the large number of applications by scientists it was possible to make teaching assignments to only 730. Many thank-you letters therefore had to be written and were late in arriving because of the large task of completing the assignments. The liaison committee knows that many very able scientists and engineers were not utilized, for there was not sufficient time to place the best qualified person in each teaching assignment.

After all the initial assignments were made and the associated correspondence taken care of, the primary concern became one of supplying replacements for scientists who later found they could not take part. About a hundred cards of unassigned scientists were catalogued with respect to possible teaching areas, and each of these groups of cards was placed in the hands of the area chairmen of the Secondary Schools Contact Committee of the Joint Board for Science Education. These scientists had been asked previously by letter to remain in a standby status. If for some reason a scientist or engineer could not meet his scheduled class, the school contact committeeman reported his particular need to his area chairman, who supplied an immediate replacement. Many last-minute assignments, substitutions, and changes were also made by telephone in the office of the science supervisor.

From the reports received to date, the effort contributed by the scientists and engineers in this Special Substitute Teacher Program was both interesting and worthwhile. One scientist, who was forewarned of a possible discipline problem, found quite unexpected and spontaneous interest in his lecture. Another found that his second scheduled class of some 30 students was, at the principal's request, extended to include the complete school of 600 students. Still other scientists have taken the time to summarize their experiences and impressions. One of these indicated that it was possible to interest only certain students, and he concluded his remarks with the observation that superior students are the ones who should receive more attention. Since the advent of these lectures, there have been reports of students asking their teachers and principals about more advanced courses in science. The suggestion has been made by several that these lectures be repeated as an annual project. A survey at one of the scientific institutions indicated that all the scientists who participated in this project would be glad to do

so again on the same basis. Other cities have also expressed an interest in this project and are making inquiries about it. Any real measure of success must, however, await future evaluation. It is hoped that those who participated and others who offered their services which were not utilized will again be generous in helping science education when called upon in the future.

ZINC OXIDE-EUGENOL DENTAL FILLINGS

Deep dental cavities have long been treated with a mixture of zinc oxide and eugenol. This white, puttylike material relieves toothache and acts against bacteria in a tooth cavity. However, quality control of such fillings has been largely a matter of experience gathered in practice over the years. Little has been known about the actual reaction taking place between the zinc oxide and eugenol—whether it is, for example, a true chemical reaction or a physical process like hydration. Since scientists did not know the precise nature of the reaction, it has been difficult to predict, much less accurately control, such things as setting time, hardness, and strength of the hardened product.

The National Bureau of Standards' dental research laboratory therefore began an investigation of zinc oxide and eugenol mixtures. The study, sponsored by the armed services' dental corps and the American Dental Association, has shown that a chelate compound is formed by these materials.[1] The compound produced, zinc eugenolate, absorbs any unreacted materials to form a hardened mass of remarkable stability. The investigations were made by Maj. H. I. Copeland, Air Force guest worker at the Bureau, Dr. G. M. Brauer and W. T. Sweeney of the Bureau staff, and Dr. A. F. Forziati, research associate, American Dental Association.

Chelate compounds are cyclic compounds formed by a coordination process, in this case with a zinc atom. Most chelates are remarkably stable. In the case of zinc oxide and eugenol, long, thin crystals are formed. The crystals act as a matrix for the set mass and absorb any unreacted material. The reaction is thus both a chemical and a physical process.

The Bureau made use of several modern techniques in its study of zinc eugenolate. Chemical procedures coupled with X-ray diffraction measurements were employed. The infrared absorption spectra of zinc eugenolate were compared to those of another chelate compound, zinc quinolate, since information with respect to the latter's structure was available from recent studies elsewhere.[2] For further comparison, guaiacol and the zinc oxide-guaiacol reaction product were employed. Elementary analysis and molecular weight determinations established the empirical formula of zinc eugenolate as being $(C_{10}H_{11}O_2)_2Zn$.

With the information that a chelate compound is formed by zinc oxide and eugenol, it is possible to predict other materials that will form like compounds for dental use. The Bureau has produced similar chelate compounds for study using guaiacol and methyl guaiacol as chelating agents. Such agents must have a replaceable hydrogen and a near-by donor group. Mixtures of zinc oxide and liquids such as phenol or veratrole cannot harden (form chelate compounds) because they do not have the required molecular structure.

Having described the reaction, the Bureau plans to compile further data on various chelate compounds and their ingredients so that the mixtures used in dental fillings may be directly controlled. Present studies in this area include determinations of the required amount of surface activity of the zinc oxide employed, optimum amount of water, mixing temperatures, and kind and amount of fillers.

CONSTANT-TEMPERATURE OVEN FOR QUARTZ CRYSTAL OSCILLATOR

The National Bureau of Standards has developed a simple, compact oven that stabilizes the temperature of a quartz crystal for precise oscillator frequency control. This oven utilizes the heat of fusion of an extremely pure organic compound—*p*-dibromobenzene—to hold the oven temperature within 0.01° of 87.31°C. Power requirements are low: 10 watts for normal operation and 20 watts during the brief warmup period. The instrument was developed for the Army Signal Corps by R. Alvarez and C. P. Saylor of the Bureau's pure substances laboratory.

Quartz crystals are widely used as frequency standards, as filters in receiver circuits, and as

[1] For further technical details, see *Setting reaction of zinc oxide and eugenol*, by H. I. Copeland, G. M. Brauer, W. T. Sweeney, and A. F. Forziati. Journ. Res. NBS **55**: 133. 1955.

[2] Merrit, L. Journ. Anal. Chem. **25**: 718. 1953.

frequency stabilizing elements in oscillator circuits. Since a temperature change in a crystal will produce a change in its frequency, common practice has been to control the temperature of the crystal in precise frequency applications. Such close temperature control is usually achieved only by relatively large and complex systems. The Bureau's special-purpose oven eliminates the need for much of the complex and bulky equipment ordinarily used.

Although the Bureau's instrument was designed specifically as a quartz crystal oscillator oven, it can be applied wherever a simple, compact thermostat for close temperature control is required. It can, for example, provide a constant temperature for a reference thermojunction for extended temperature measurement and control. The oven uses *p*-dibromobenzene in its particular application, but other substances with different melting points provide other operating temperatures. Phenoxybenzene, for instance has been employed in maintaining quartz crystals at a constant temperature of 26.88°C. where the ambient temperature is low.

When a substance is partially molten, its latent heat of fusion provides thermal ballasting; that is, a heat loss causes crystallization of the material with evolution of the latent heat of fusion. A heat gain, on the other hand, results in absorption of heat as the solid phase melts. The melting temperature at the solid-liquid interface remains unchanged, provided that the material is pure and that the pressure is constant. A substance used for temperature control in this way must possess (1) a melting temperature within the desired operating limits, (2) extreme chemical stability when in contact with the oven components, (3) a high heat of fusion, and (4) a high velocity of crystallization. *p*-Dibromobenzene meets these requirements.

The oven is contained in a cylinder $3\frac{1}{32}$ inches high and $2\frac{11}{32}$ inches in diameter, mounted on an octal base. Inside the oven is a vacuum-tight container into which a quantity of paradibromobenzene has been sealed. During operation of the oven, the material is about half liquid and half solid, and completely fills the container. At the top of the container is a metal bellows that is linked to a spring-loaded miniature switch. The volume changes occurring during phase transformations are transmitted to the bellows, which turns a heater on or off to keep the chemical partially molten. Spring-loading the switch provides a pressure relief system in case a greater proportion of liquid is formed during the warmup period than would be present at the normal operating point. A second heater provides rapid warmup. It is controlled by a bimetallic element that cuts off the power when the substance is about 7° below the melting point. A copper vane system distributes the heat rapidly throughout the container and reduces any temperature gradients that might exist if solid and liquid become separated during operation. The crystal and its holder fit into a well within the container.

Temperature stability data on the instrument were obtained by fastening a calibrated thermistor to a dummy crystal inside the crystal holder. The total temperature variation during a six-day period of continuous operation did not exceed 0.007°C.

NEW CHIEF OF NBS METALLURGY DIVISION

Dr. James I. Hoffman has been selected to head the Bureau of Standard's Metallurgy Division. He succeeds Dr. John G. Thompson, who recently retired.

An outstanding analytical chemist who developed one of the first methods for purifying uranium, Dr. Hoffman had been serving as assistant chief of the Bureau's Chemistry Division and Chief of the Surface Chemistry Section. The Department of Commerce recently honored his work by awarding him the Gold Medal for Exceptional Service. In his new capacity he will direct the Bureau's diversified program in metallurgical research and development. Author of numerous publications in his field, he is well known for his work on the chemistry of the rarer elements and the chemical analysis of iron, steel, refractories, and various minerals, such as phosphate rock, bauxite, and fluorspar. He has taught analytical and physical chemistry at George Washington University, American University, the Department of Agriculture, and in graduate courses given at the National Bureau of Standards.

In 1946 Dr. Hoffman was awarded the Hillebrand Prize for significant contributions to chemical science. His specific achievements were listed as the determination of the atomic weights of aluminum and gallium, the construction of a pilot plant for the production of alumina from clay, and the development of an ether extraction process for the purification of uranium oxide. The purification of uranium oxide by this method

removed the greater part of the difficulties encountered by the Manhattan District in securing pure materials for the production of uranium metal. The process perfected by Dr. Hoffman for obtaining alumina from clay was the result of an effort to utilize domestic sources of alumina at a time when submarine warfare was seriously interfering with shipments of bauxite to this country.

ROCKEFELLER PUBLIC SERVICE AWARD TO DR. FANO

Dr. Ugo Fano, chief of the Nuclear Physics Section of the National Bureau of Standards, has been granted a Rockefeller Public Service Award, which will allow him to complete a book on quantum physics for nonphysicists. Dr. Fano is internationally known for his theoretical work in various branches of physics and in related sciences. An authority on the penetration and diffusion of radiation through matter, his theories are widely used in connection with nuclear reactor shielding problems. An important part of his work at NBS is consultation with experimental scientists on the theoretical aspects of their work.

In this work Dr. Fano has shown a unique ability to explain the fundamental concepts of classical and modern physics in terms and analogies that scientists working in other fields such as biology and medicine can readily understand. Since the number of scientists who have need for this type of information is steadily increasing, Dr. Fano's book would be an important contribution to the literature.

The award will also give Dr. Fano the opportunity to accept an invitation to spend the 1956 academic year teaching at the University of Rome. He has been invited to lecture on subjects of his own choice, working in line with the University's program for developing peaceful applications of atomic energy.

Born in Torino, Italy, in 1912, he received his D.S. degree from the University of Torino in 1934. After his graduation he worked in Rome under the direction of Prof. Enrico Fermi, serving as an instructor. During this period he held also a fellowship at the University of Leipzig, under Prof. Werner Heisenberg. He came to the United States in 1939, serving first as a research associate at the Washington Biophysical Institute. From 1940 to 1946 he worked with Dr. Millislav Demerec in genetics and radiobiology at the Carnegie Insitution of Washington, joining the NBS staff in the latter year.

A RAPID QUANTITATIVE ANALYSIS OF COLLAGEN

A method for measuring the amino-acid content of collagen in a relatively short time and using simple apparatus has been developed by the National Bureau of Standards leather laboratory.[1] The procedure, an application of 2-dimensional paper chromatography, was worked out by James M. Cassel by modifying and adapting a recently published qualitative method.[2] The quantitative technique can be applied not only to collagen, the parent substance of leather, but also to the derivatives and degradation products of collagen. In contrast to other methods currently employed, it enables the analyst to follow with a high degree of detail the reactions and changes in which collagen may be involved. It is therefore expected to provide a useful tool in understanding the structure of collagen and the properties of leather.

Improvements in technique during the past few decades have made chromatography one of the more important methods available to the analytical chemist. The partition chromatographic process brings about separation of components in a mixture by distributing the solutes between two liquid phases, one of which is mobile and the other essentially fixed by sorption to a support, i.e., to a column of silica gel or to a sheet of cellulose paper. In one form of the method, a small quantity of unknown mixture is applied to one end of a strip of paper and that end placed in an appropriate irrigating solution. The solution rises by capillary action and carries the mixture with it. Mainly because of differences in solubility, however, the various components move up the support medium at different rates. After a period of time, the components are spread out into a series of separate patches.

The use of paper as the chromatographic adsorbent has broadened the range of application of the method and, at the same time, has made

[1] For further technical details see *A paper chromatographic analysis for collagen and collagen derivatives*, by JAMES M. CASSEL, Journ. Amer. Leather Chemists' Assoc. (in press).

[2] *Two-dimensional paper chromatographic system with high resolving power for amino acids*, by R. REDFIELD, Biochim. et Biophys. Acta **10:** 344. 1953. The first description of paper chromatographic methods for the analysis of protein hydrolysates was given in 1944 by Consden, Gordon, and Martin.

it accessible to even the most modestly equipped laboratories. The use of paper also facilitates two-dimensional chromatography. If a drop of unknown mixture is applied to a corner of a paper square and solution is passed through the paper parallel to one of the edges, the unknown will spread out into a line of patches along one edge of the square. Often, however, the separation is not complete, some of the patches being still made up of several components. If now another solvent is passed through the paper perpendicularly to the line of patches, each of the latter may be split up into several patches, the final result being a 2-dimensional pattern of patches on the paper.

The Bureau's method produces separation of all eighteen of the amino acids of collagen, with the exception that lysine and hydroxylysine are separated as a single entity, as are also leucine and isoleucine. The procedure is simple and requires for accurate analysis as little as 150 micrograms of protein per chromatogram. If certain precautions are observed, very good reproducibility of data is obtained.

The first step in the procedure is to apply, by micropipette, a small spot of the solution to be analyzed to the corner of a sheet of Whatman No. 1 paper, 37 cm square. The sheet is then stapled in the form of a cylinder and placed spot downward in a glass cylinder, 6 inches in diameter and 12 inches high, containing the solvent mixture. A crystallizing dish is inverted and sealed to the top of the chamber with electrical tape to serve as a tight sealing lid.

The paper is irrigated in the first direction with a mixture of methyl alcohol, water, and pyridine. After this, it is removed, dried, restapled, and then irrigated in the second direction with tertiary butanol, water, and diethylamine. Once again the sheet is dried, and the last traces of diethylamine are removed by hanging the sheet in a steam hood at 75°C. for approximately seven minutes. An alcohol solution of the coloring agent ninhydrin is sprayed on the sheet, and the color is developed under carefully chosen conditions of temperature and humidity.

At this point the chromatographic separation of the amino acid components, with the exceptions noted, is complete, each component appearing as an irregular, colored patch on the paper. Each of the spots is now cut out and then cut into small strips. The strips, in turn, are placed in test tubes and washed out with fixed quantities of aqueous n-propanol. Optical densities are then read with a spectrophotometer set at 570 mμ for all components except proline and hydroxyproline, which are read at 350 mμ. Finally, the amount of each amino acid present is determined by comparing the optical densities with calibration curves obtained from standard solutions run in the same manner.

Amino acid values for collagen as determined by this technique agree well with those reported in the literature. If four to eight chromatograms are run per sample, quantitative information concerning all the amino acids in either collagen, a collagen derivative, or a collagen degradation product can be obtained in only four or five days. If conditions are maintained constant throughout the procedure, standards need not be run simultaneously with the unknowns and hence an important saving in labor and time is achieved.

The development of a rapid quantitative analysis for collagen is part of a larger program of research which the Bureau is conducting on the physical constants and structure of leather. Basic information on leather and collagen, the principal constituent of cattle hide, is needed to assure continued advancement in methods of tanning and leather manufacture. Related investigations now in progress deal with the pore structure of the leather matrix, specific heats of collagen and leather, and the effects of high pressure. The Bureau's method for analyzing collagen is being applied to a study of the reaction of collagen with nitrous acid. It is also planned to use the new technique to obtain information about the layerwise distribution of amino acids in hides and the effect on the distribution produced by various types of degradation processes.

BISON BASIN FOSSILS

An isolated Wyoming valley has yielded a considerable collection of fossil remains of archaic mammals of about 60 million years ago, animals only remotely related to those living today. The fossils from this locality, known as the Bison Basin, first discovered by a Geological Survey party four years ago, have just been described by Dr. C. Lewis Gazin, curator of vertebrate paleontology at the Smithsonian Institution, who had a major part in collecting them.

The creatures lived during the Tiffanian epoch, next to the last subdivision of Paleocene geologic time—a period that lasted approximately 20 million years but which was just the start of the

"Age of Mammals." The Paleocene was the time when mammals were coming up as the dominant animals on earth and the importance of the dinosaurs had just passed. The warm-blooded creatures were becoming markedly diversified, filling many of the habitats left by the disappearance of the host of reptilian forms which previously ruled the earth.

Notable in the collection are remains of plesiadapids. These were small, probably tree-climbing animals belonging to the primate order, but only remotely related to the living New or Old World monkeys. They were most like lemurs, and are classified in the same superfamily, but the living lemurs may not have been derived from the plesiadapids but from some closely related contemporary.

Plesiadapids were not only North American in distribution but are known also from the Paleocene of France, from beds about the same age as our North American Tiffanian time. The Bison Basin beds in Wyoming produced at least four species and two genera of these creatures, represented by teeth and jaws. Among them is one of the most primitive known of the family, a rather minute creature known as *Pronothodectes*. In the Bison Basin beds this represents a survival of the group recognized as the precursor of true *Plesiadapis*. Present also is one of the most advanced of the plesiadapid family, not in the same beds but stratigraphically higher than the level which produced the most primitive. They just happened to have died in the same general locality, Dr. Gazin says, but at different times.

Among other creatures represented are condylarths—archaic, subungulate mammals that paleontologists now generally believe gave rise to the modern hoofed or ungulate animals. The condylarths themselves, however, were not truly hoofed but had toes with structures intermediate between claws and hoofs. They show evidence that the claws at this stage were beginning to spread out or flatten. Some of the condylarths were very small; the largest of those in the Bison Basin, however, was *Phenacodus*, an animal over 4 feet long and about 2 feet high. It may have looked rather like a carnivore, but its teeth demonstrated that it was an herbivorous type. At that time the condylarths and the creodonts, the latter including the forerunners of the true carnivores, were not so greatly different in structure.

The Bison Basin collection also contains fossil remains of several kinds of creodonts, including the miacids that later gave rise to the more modern carnivores, and such creatures as claenodonts, animals that probably had somewhat the appearance of small bears but were definitely not ancestral to them.

A pupil began to learn geometry with Euclid and asked, when he had learnt one proposition, "What advantage shall I get by learning these things?" And Euclid called the slave and said, "Give him sixpence, since he must needs gain by what he learns."—Sir T. L. HEATH, *A History of Greek Mathematics.*

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